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HAWAII AGRICULTURAL EXPERIMENT STATION
E. V. WILCOX, Special Agent in Charge.

ANNUAL REPORT

OF THE

HAWAII AGRICULTURAL EXPERIMENT STATION

FOR

1908.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS.
U. S. DEPARTMENT OF AGRICULTURE.

HONOLULU:
HAWAIIAN STAR PRINT.
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[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

Walter H. Evans, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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LETTER OF TRANSMITTAL

HAWAII AGRICULTURAL EXPERIMENT STATION,
Honolulu, Hawaii, January 4, 1909.

SIR: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Hawaii Agricultural Experiment Station for the fiscal year 1908.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

DR. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

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ANNUAL REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION FOR 1908

SUMMARY OF INVESTIGATIONS.

By E. V. Wilcox, *Special Agent in Charge.*

The investigations described in the accompanying report were all begun under the supervision of the former special agent in charge, Mr. Jared G. Smith, who severed his connection with the station at the end of the fiscal year. The report, however, was prepared under the direction of the present special agent.

During the year considerable attention was given to the improvement of the general appearance of the station grounds and buildings. A number of old and unsightly structures were torn down and replaced by others more serviceable and of better appearance. One structure was erected to contain a tool house, seed storehouse, and carpenter shop, on the ground floor, and a rice laboratory in the second story. An addition was made to the stable, in which a blacksmith shop and implement shelter are provided. The experimental grounds and pastures were surrounded with new and substantial fences, and about 5,000 feet of new pipe line was laid for irrigation purposes. In addition to these changes and alterations, an old office building was torn down, and a new 5,000 gallon water tank was erected near a 2-acre rubber plantation on the slope of Tantalus at an elevation of about 700 feet.

The leases held by the station on lands for growing rice, cacao, and bananas have been given up, except for the rice trial fields, which are conveniently situated and are in excellent tilth. The other leases were abandoned on account of the distance of the lands from Honolulu and the difficulty of supervising the experiments under the present appropriation.

During the year the station published Press Bulletin No. 20, on The Introduction of Top-Minnows into the Hawaiian Islands, by D. L. Van Dine, and the following Bulletins, in the regular series of the station: No. 14, Marketing Hawaiian Fruits, by J. E. Higgins; No. 15, Cultivation of Tobacco in Hawaii, by Jared G. Smith and C. R. Blacow; No. 16, The Ceara Rubber Tree in Hawaii, by Jared G. Smith and Q. Q. Bradford; and No. 17, Hawaiian Honeys, by D. L. Van Dine and Miss Alice R. Thompson.

The correspondence of the station related chiefly to the supervision of field experiments, the distribution of economic plants to the islands, the introduction of new plants or varieties, advice regarding cultural details of various crops, the control of insect and fungus enemies, and suggestions to prospective settlers in reply to inquiries regarding prospects for farmers in these islands. Various localities on all of the important islands were visited during the year by the station staff, and the horticulturist made a trip to the mainland in the investigation of fruit shipping. The station assisted in a horticultural and agricultural exhibit in coöperation with the Hawaiian Poultry Association. Members of the station staff also gave lectures at meetings of the farmers' institute and in connection with the work of the College of Hawaii.

CHEMICAL INVESTIGATIONS.

The principal chemical work of the year was of an analytical nature and was concerned chiefly with the determination of the composition of paddy, rice straw, and rice grain. This work was done in coöperation with the rice investigations of the station. Analyses were made of several varieties of rice, particularly imported Japan rice, Japan rice grown in Hawaii, and Hawaiian Gold Seed rice. The analyses showed that the claims which have been made for the greater nutritive value of imported Japan rice, as compared with Japan rice grown in Hawaii, are not well founded. In fact, Japan rice grown in Hawaii appears to be slightly more nutritious than that imported directly from Japan. The composition of rice straws is not quite so constant as that of rice grain. It was found that dry-land rice takes up less lime and more phosphoric acid than rice grown under submerged conditions.

Analyses were also made of rice hay as fodder, Rhodes grass, cassava waste, wheat hay, cowpea, jack bean, pigeon pea, castor pomace and peanut meal. In connection with pineapple investigations, analyses were made of soils from pineapple fields. As a rule, the lime content was found to be low. Potash and available phosphoric acid were also somewhat deficient. In some cases, the lime content was higher than that of magnesia, while in other cases the conditions were reversed.

Analyses of drainage water, from lysimeter experiments, showed that the use of ammonium sulphate as a fertilizer causes loss of lime in the soil. Analyses were made of wax left in slum-gum and also of koa bark and ohia bark. In a pot experiment with fertilizers for Hevea rubber, it was found that sodium nitrate gives good results, while acid phosphate affects rubber trees unfavorably.

RUBBER.

The chief results from the rubber investigations of the year were published in Bulletin 16. During the last quarter of 1907, experiments were made in planting Hevea rubber seeds. They germinated and grew best when the shell had been removed and the seeds planted in clean sand. The herring-bone system of tapping on Ceara rubber trees gave quite favorable results. In some experiments on Kauai it was at times found difficult to coagulate the latex. This was accomplished, however, by the addition of hydrogen peroxide and sulphuric acid. As many as thirty consecutive tappings were made by excising a thin slice of bark from the old wound, and a good flow of latex was obtained during the whole period. The use of a water bag, or an ammonia bag, was found to increase the relative amount of first-grade rubber as compared with scrap rubber. By tapping yearling trees it was found that the yield differed greatly. This point may be of value in indicating which trees should be cut out, and which ones should be kept in the plantation to increase the total yield.

ENTOMOLOGICAL INVESTIGATIONS.

The insect collection and reference library have been considerably increased and a steady improvement has been made in the systematic arrangement of this material. The chief lines of entomological work during the year were studies of insects affecting domestic animals, pineapples, cotton, mangoes, and apiculture. A survey was made of the cattle ranges for the purpose of determining the status of the horn fly. This insect is perhaps more injurious in these islands than on any part of the mainland, occuring in immense swarms and attacking not only cattle, but also other animals. An attempt is being made to introduce natural parasites of the horn fly to supplement direct and indirect insecticidal measures, such as treatment of cattle dung and spraying infested cattle. The problem is recognized as a difficult one on account of the universal distribution of the pest in the islands and the half-wild conditions under which range cattle live. In the case of dairy herds and work oxen, the problem is somewhat simpler.

Great losses have been suffered from sheep-maggot fly (*Calliphora dux*), which has changed its habits so as to become a parasitic insect. The insect deposits its eggs on wounds, in areas infested by the sheep-scab mite, or in soiled wool. The larvae make their way into the tissues underneath the skin, causing suppuration and septicemia, followed by death, unless a suitable treatment is administered. The investigations thus far made indicate clearly that in order to control this pest it is absolutely necessary that all sheep carcasses should be promptly buried. In this way the excessive multiplication of the sheep-maggot fly will be checked, for the favorite breeding ground of the pest is in carcasses. It has also been found necessary to destroy eggs and maggots in infested pens and corrals.

The entomologist has devoted considerable time to the investigation of apicultural problems and the encouragement of bee raising. The honey crop of the islands for the year will amount to nearly 1,000 tons. Available locations for apiaries have been largely taken up, but there is still room for extension. A survey has been made of the honey-plants of the islands and a number of new honey-plants, which are also useful for other purposes, have been introduced. The present list of good honey-plants in the islands is extensive. In order to prevent the possible introduction of foul brood, an act was passed by the Territorial legislature providing for the careful inspection of imported bees and honey.

The great extension of the pineapple industry has called attention to certain injurious insects, particularly scale insects and mealy bugs. A number of fumigation tests were made in which effective doses were determined for fumigating pineapple suckers and offsets before planting, and also for treating pineapple fruits before shipment to the mainland. As a result of the recommendations based upon these experiments, the shipment of fresh pineapples to the mainland has been accomplished with striking success.

The station has for the time closed its work in the investigation of mosquitoes, the important facts concerning their life history and suppression having been determined and published. The control of mosquitoes is now in the hands of the Territorial authorities.

A revised list has been prepared of the injurious insects of Hawaii, and also of the additions to the entomological library relating to Hawaiian entomology.

A new insectary has been erected and equipped (see Pl. I). It is built on sewer pipe piers set in cement basins filled with water. The steps are separate from the building and the building is insect proof.

HORTICULTURAL INVESTIGATIONS.

The chief work of the year was done in studying the problems of shipping fresh fruit, including pineapples, avocados, papayas and bananas. The demonstration of the possibility of shipping pineapples and avocados as far as Chicago was followed by commercial shipments to various inland cities. The great increase in the acreage of pineapples has called attention to the necessity of further developing the fresh-fruit markets, and the results thus far obtained are encouraging.

A rearrangement of water pipes in the orchards of the station has made it possible to irrigate more conveniently and satisfactorily. Much attention has been given to cover crops for

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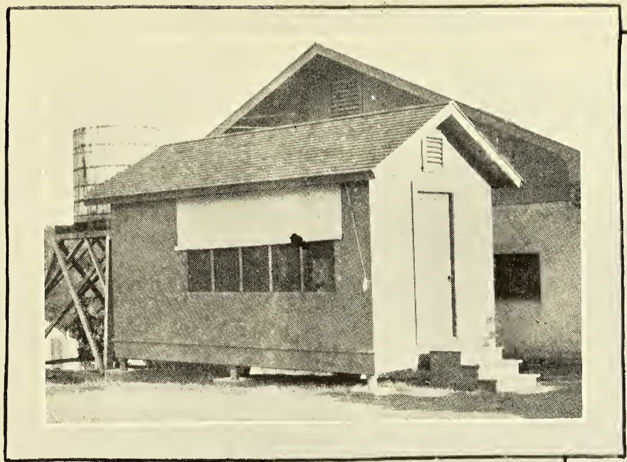
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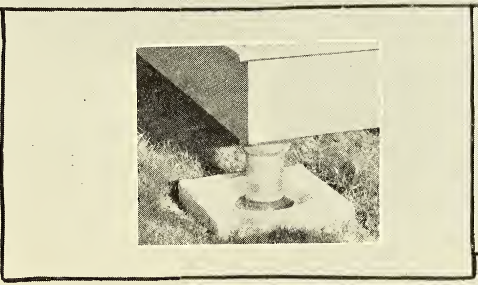
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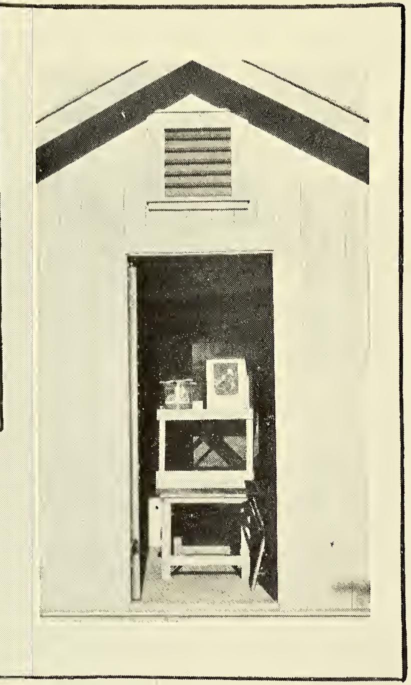
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Fig. 1. New Insectary built on sewer pipe piers resting in cement basins filled with water.
Fig. 2. Detail of pier. Fig. 3: Interior showing breeding cages.

orchards. On steep grades cover crops are necessary to prevent washing during the occurrence of heavy showers. Since growth continues during the whole year, it is necessary to keep the ground free from the cover crop for a short distance around each tree. The cover crops chiefly used so far are cowpeas, pigeon peas, and jack beans. Cowpeas make the quickest growth, but are quite susceptible to the attacks of insects. Pigeon peas require longer to reach maturity. The jack bean makes a lower growth but is a good cover and is exceptionally free from insects. The ordinary insect pests have been kept in check by repeated spraying with kerosene emulsion; and by the use of a sticky mixture to keep ants from the trees.

The rough lemon has proved to be an excellent stock for use in establishing citrus orchards. An extensive budding test is in progress. More than forty varieties of bananas are growing on the station grounds. It has been found necessary to establish a nursery to supply the demands which are made for certain varieties; otherwise the experimental work would have been interfered with. Several of the varieties now grown at the station were imported from Porto Rico, and the native varieties have been collected from various parts of the Territory.

In work with mangoes, 80 per cent of the buds of Alphonse mango have grown. The results are not always so satisfactory with all varieties. It has been shown that budding must be done in the early part of the season of active growth. Mango trees two or three years old may be safely transplanted. In experiments at the station nearly all the trees transplanted at that age quickly started into growth whether the roots were freed from soil in the process of transplanting or had been enclosed in a ball of wet earth. Inarching appears to be the surest means of propagating fine varieties of mangoes, but is rather more expensive than budding. (See Plate II). In shipping experiments with young mango trees, it was found that a large percentage of them will be lost in transit unless care is taken to select trees with firm wood and a dormant terminal bud.

Attention has been given to the study of the flowering period of the mango, which appears to vary from year to year. The station has added more than three hundred varieties of plants to its horticultural collection during the year. Of this number, special mention should be made of henequen, pineapple varieties (from the Department of Agriculture), wampi fruit, cherimoya, litchi, camphor, and the Victor variety of roselle. A constantly increasing call is made for plants and cuttings for distribution in different parts of the islands; and the station has complied with these requests in so far as the facilities and experimental work would allow.

The horticulturist has given considerable attention to the encouragement of deciduous plantings at high altitudes on the island of Hawaii, and to a study of the problems connected with the production of red peppers.

RICE INVESTIGATIONS.

General interest in rice investigations is increasing from year to year, and the expert in charge of this work has been called upon for advice and technical help in the fertilization, culture, harvesting, milling, and other processes connected with rice production.

A variety known as No. 19, originally from Ceylon, has proved to be an exceptionally heavy yielder and is especially adapted as an export crop for consumption by Chinese upon the mainland. It is best used as a fall crop. Variety No. 65, an Egyptian rice, has given excellent returns in dryland culture. The yield is satisfactory. The variety promises well as a hay crop on account of its smooth glumes and large yield.

During the year an elaborate series of fertilizer experiments was carried on with rice. It was shown that when fertilizers are applied to rice after the crop is two-thirds grown the first crop receives the least benefit, and the succeeding crop shows the greatest residual effect of the fertilizer. If, on the other hand, the fertilizer is applied before planting the first crop of the season, this crop takes up nearly all of the fertilizer, while the second crop receives little or no benefit. In pot experiments it was shown that there is no residual effect of nitrate of soda upon the second crop, even though the application be made at a late stage of growth of the first crop. The greatest residual effects upon the second crop have been produced by the use of sulphate of ammonia and fish guano. Experiments in pot and field culture have demonstrated that rices which mature slowly receive the most benefit from fertilizers which become available slowly, for example, sulphate of ammonia.

In direct fertilizer experiments, in which the residual effect upon the second crop was disregarded, a comparison was made between sulphate of ammonia, lime nitrogen, and nitrate of soda. The sulphate of ammonia doubled the yield, as compared with unfertilized rice, and gave much better results than either lime nitrogen or nitrate of soda. The last named source of nitrogen appeared to give little benefit in increased growth, except when applied after the crop was two-thirds grown. In dry-land culture of rice muriate of potash produced striking results. The experimental results, obtained in pot and field cultures, have attracted much attention and the station has been called upon to plan a scheme for the systematic fertilization of a large rice plantation. This plan has already been put into effect.

The lack of natural hay crops in the islands, and the consequent heavy drain upon the resources of farmers in buying imported hay, suggested to the station the desirability of a study of upland rice as a hay crop. It has been found that 2½ inches of water per week, during the growing season, is necessary to insure a paying crop. Our experiments have also demonstrated the desirability of deep and thorough tillage and light seeding.

Salt marsh rice has also been tested as a hay crop. Rice grown on salt marshes is inferior in quality of grain, but has been demonstrated to be an efficient substitute for imported hays. It is believed that a portion of the $250,000 annually paid for imported hays may profitably be devoted to the production of a home crop of salt marsh rice for hay. The total weight, in a green condition, of salt marsh rice is about 14,000 pounds per acre, valued at $73. No difficulty has been experienced in securing such hay in a well cured condition. The feeding experiments thus far made with this material have shown that it is relished by cattle and horses and that its nutritive value is satisfactory.

EXPERIMENTS WITH MATTING SEDGES AND RUSHES.

For two years experiments have been carried on with Chinese mat sedge (*Cyperus tegetiformis*), and Japanese Bingo-i mat rush (*Juncus effusus*). Three harvests have been made of these matting plants at the rice trial grounds and a large planting has been made on the windward side of the island of Oahu. The yield from the Chinese mat sedge has been at the rate of 8,700 pounds per acre of the 60-inch length; 5,700 pounds of the 48 to 60-inch length; and 5,200 pounds of the 30 to 48-inch length. The crop requires from six to seven months from planting to maturity, and five months for the rattoon crop. Sample reeds of the Chinese matting sedge were forwarded to a factory on the mainland, and flattering reports were received as to their quality. A small sample of woven mat was made from the material. The greatest difficulty in the way of making this crop a financial success consists in the fact that each reed must be split. With the invention of a machine for doing this work, the crop promises to be profitable and can be grown in brackish marshes, which would otherwise be useless. The Japanese matting rush does not require splitting and is improving with each crop, but has not yet attained a sufficient length for profitable handling.

COTTON EXPERIMENTS.

Fifty years ago Sea Island cotton was grown in these islands, but the industry was allowed to lapse. The station has been experimenting with Sea Island and Caravonica cottons with striking results. The yield is high, the fiber of good length, strength and luster, and the percentage of lint ranges from 30 to 40. All varieties of cotton thus far tested grow as perennials in these islands, and the shape of the trees and the time of maturing the bolls may be controlled by pruning.

MISCELLANEOUS CROPS.

Several varieties of soy beans have been grown for use as fodder, green manuring, and human food, particularly in the Japanese product, Miso. The yields have been very encouraging. About 500 tons of soy beans are annually imported from Japan, and the demand is increasing. These beans are sold in Honolulu for $3 per 100 pounds. The market can easily be supplied by home production.

Peanuts have yielded gratifying results in various localities. On the trial grounds of the station a number of varieties have been grown, including Spanish, Bunch Jumbo, Running Jumbo, and Virginia Running.

REPORT OF THE ENTOMOLOGIST.

By D. L. Van Dine.

INTRODUCTION.

The entomologist visited during the year the islands of Hawaii, Maui, Kauai, Molokai, and all the outlying districts on the island of Oahu. Two trips were made to the island of Molokai, where the opportunity for observations on bee-keeping and live-stock insects are exceptionally favorable.

The office record relating to injurious insects in Hawaii in general and to particular groups or species in detail, the collection, and the reference library show a steady growth. This material will be so arranged that the information at hand will be available for use without loss of time, and further, so that accessions may be made without adding confusion. It is the purpose to work toward a systematic arrangement which will permit the use at any time of the results of entomological investigations throughout the world in so far as they are applicable to the peculiar climatic and economic conditions of Hawaii.

The important lines of work during the year were investigations relating to the insects affecting live stock and bee keeping. On Oahu, further work was undertaken on the insects affecting pineapples, cotton, and mangoes.

The insects affecting live stock in Hawaii are second only in economic importance to those injurious to sugar cane. Some of the species of this group of pests are known to stockmen, and the status of one especially, the horn fly, is well understood. There are several live-stock pests recorded from Hawaii the local status and occurrence of which have not been definitely ascertained, as for example the horse botfly, the stable fly, and the sheep head-maggot fly; and there are still others which are not even recorded, as the two recently determined species of blow or maggot-flies affecting sheep. An effort is being made on the natural-enemy phase of the control of the horn fly and there is a possibility of relief from this source, but the general statement can be made that as a group the insects affecting live stock in Hawaii exact their heavy annual tax unhindered and, in some instances, unrecognized.

The investigations relating to the insects affecting live stock in Hawaii were undertaken jointly by the writer and Dr. V. A. Nörgaard, Territorial veterinarian and veterinary inspector of the Bureau of Animal Industry of the U. S. Department of Agriculture. The writer is responsible for the entomological work and Dr. Nörgaard has in charge the pathological investigations relating to the subject. The notes on the horn fly and the sheep-maggot fly are taken in the main from a joint report to the Hawaiian Live-Stock Breeders' Association.*

The interest at present being shown in the production of cotton in these islands will necessitate some consideration of the insects affecting the cotton plant. A large number of insects attack cotton, and the combined effect of their injuries on the growth of the plant and the quality of the staple offers a more or less serious menace to the success of cotton growing.

The worst injury is done by a small boll worm (larva of a Tineid moth, *Gelechia gossypiella*), which seems to be identical with the "pink-spotted boll worm" affecting cotton in India. The Japanese beetle (*Adoretus umbrosus tenuimaculatus*) skeletonizes the leaves. A mealy bug (*Pseudococcus filamentosus*) produces considerable injury on young plants and about forming buds and bolls, and the tender foliage and blossoms suffer from the attacks of an aphid. The cotton boll worm (*Heliothis obsoleta*) of the southern United States is found on tobacco and corn in Hawaii, but if cotton planting becomes extensive its spread to this crop may be anticipated.

The determination and study of the life histories, habits, and injuries of these pests will be a feature of the coming year's work.

As in the past, the writer is pleased to record the courtesies received from co-workers in Hawaii and abroad, and would point especially to the aid and advice given by Dr. L. O. Howard, Chief of the Bureau of Entomology of the U. S. Department of Agriculture. The writer would mention here also the kindly suggestions and helpful support received from Mr. Jared G. Smith, Special Agent in Charge of this station.

THE HORN FLY.

(*Haematobia serrata*).

The horn fly was introduced into Hawaii with shipments of cattle from the western coast of the United States to the island of Oahu during 1897. Within a year it had spread to all the other islands. In the ten years that have since elapsed, it has bred uninterruptedly, and the annoyance caused by its blood-sucking habit has been felt during this time by all the thousands of cattle on Hawaiian ranches. The smaller dairy herds have likewise suffered. Horses are bothered to some extent by the fly, especially when near cattle. Recently, Nörgaard has pointed out the complication of sheep-scab and horn fly injury on sheep.* To this complication has been added, later, that of the maggot flies, which in many cases take up the work of destruction in connection with, or subsequent to, the injuries caused by the scab mite and horn fly.

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* Report of the Division of Animal Industry, Rept. Bd. Commrs. Agr. and Forestry, Hawaii, 2 (1905,) pp. 171, 211,212.

While the horn fly in the United States and Canada causes more or less loss to the live stock and dairy industries, it is checked in these countries by two distinct seasons, a cold and wet and a hot and dry season. As warm wet weather is required for the continuous development of the horn fly, it would seem that the Hawaiian Islands offer an especially favorable breeding ground for this pest. The horn fly requires but little rainfall, and finds here an equable temperature, varying but slightly with the seasons, and at no time detrimental to its propagation. Prolonged drought will check it, ordinary dry weather retard it, but climatic conditions which might be called destructive to it rarely occur here. It is, therefore, little wonder that, once introduced here, it required but a short time to spread all over the Territory and to multiply to such an extent as to make Hawaii compare with the worst infested sections of the mainland.

The two lines of control that are offered for the horn fly are, as with all insect pests, preventive and curative measures. Prevention includes the destruction of the larvae in cattle dung by direct measures or by the introduction of natural enemies that will feed upon them. Curative measures include protection of the cattle from the attacks of the fly or the wholesale destruction of the adult flies. All of these methods of control have received serious consideration as evidenced by the many reports dealing with the treatment of cow dung to destroy the breeding place of the larvae, the introduction of natural enemies from one country to another, the spraying of cattle with repellent mixtures and trapping and spraying experiments to destroy the adult fly. These various methods and their application must be considered with reference to Hawaiian conditions. The use of repellents does not appear feasible in Hawaii except in the case of our dairy herds, and even there they should be used only in conjunction with preventive measures for the destruction of the larvae in the dung. Prevention, therefore is the keynote to the control of the horn fly.

The large areas comprising the cattle ranges and the semi-wild condition of the herds give emphasis to the idea that the only hope of permanent relief for beef cattle lies in procuring effective natural enemies. The serious menace that faces cattle raising so long as the horn fly ravages remain unchecked, justifies the continuation of efforts to procure such enemies from abroad, and to establish and encourage promising species already within the Territory. This phase of control work, however, should not deter the stockmen from doing their share toward the suppression of the pest, as natural enemies do not become a factor until they are obtained and established. In other words, while supporting investigations relating to this work, ranchers should not allow the possibility of direct measures of control to pass from their minds.

Great benefit could be derived were it possible to destroy wholesale the adult flies on cattle in the fattening paddocks. It is a well-known fact that cattle in a fattening paddock cannot be finished for market while the flies are bad even when their feed is abundant. It would be highly desirable to submit such cattle to one or two dippings or sprayings, providing such operations would afford perfect rest to the cattle for at least a month or six weeks before going to market. However, it is only where the application of such remedies can be made on a scale promising returns in proportion to the time and labor expended that they can be considered.

The habits of horn flies are such that they never fly any great distance from the cattle or leave them for any length of time. Whether they rest on foliage or grass in any numbers is not known, but it is safe to conclude from the observations made by many investigators and from our own experience that when all of the animals in the pasture are rounded up, nearly all of the adult flies are around the animals, including the cow-ponies. As the flies are very light and as they are easily carried by the wind, to free a pasture from adult flies would require that all animals be rounded up and driven with the wind out of the pasture and then put through the dip or spray and back into the same pasture against the wind. To prevent any of the flies returning with the cattle it might be well to build a funnel-shaped canvas-covered guard at the entrance to the place of treatment and a long brush-covered chute at the exit. Two weeks after the first treatment the operation should be repeated, in order to destroy the horn flies which have since developed. It is a safe conclusion that all of the flies which are left behind and which are not destroyed in the treatment will assemble on or around the horses of the cowboys and annoy them greatly, and if any cowboy returns to the (presumably) clean pastures, thousands of flies will follow.

Still better results might be obtained if the pasture to be freed from flies could be left empty for two to four weeks after the cattle and flies have been removed, but until something definite is known as to what becomes of horn flies which are hatched in the pasture where there are no animals to feed on, how long they can live without food, and what distances they will travel in search of food, nothing certain can be said in regard to the length of time the pasture should be allowed to rest, to completely free it from the flies. From deductions made from observations of other species, it is, however, safe to conclude that the above-mentioned period, two to four weeks, would be sufficient for the great majority of them to disappear.

To attend to the droppings of animals, however small the number or however easy the method, is practically out of the question except on dairy ranches. It has been estimated that perhaps 50 per cent of the developing flies can be found in the dung in the vicinity of watering places, pens, and shady retreats.

The cakes are found in greater numbers and more eggs are probably deposited in them than in those which are dropped over the range. The same applies to cattle yards near dairies or farms where the animals are being held at milking time. Appropriate treatment of the dung in these places would destroy a proportionately large number of larvae.

A still less expensive method of scattering the dung in yards and pens is to allow a number of pigs to run with the cattle. In their efforts to obtain undigested particles of food they will effectively destroy the cakes as breeding places for the fly larvae, at least during the dry season. This is especially noticeable in feed yards on the mainland where hogs sometimes follow cattle, and, to a certain extent, in the algaroba belts of these islands.

That the prevalence of insect pests in the Territory is due, to a great extent, to the almost total absence of insectivorous birds, can not be doubted. The writer has conferred with Prof. H. W. Henshaw in regard to the introduction of birds, particularly those that are destructive to flies. Prof. Henshaw is familiar with the conditions in these islands and offers every encouragement to the hope that desirable birds can be found. The necessity of studying carefully the feeding habits of any bird introduced, before it is liberated, has been pointed out by all who have been consulted, and for this purpose an observational aviary will be established in connection with the Pacific Scientific Institute. The station has arranged to work in coöperation with Mr. W. A. Bryan, President of the Pacific Scientific Institute, in its efforts to secure valuable insectivorous birds.

THE SHEEP-MAGGOT FLY.

(*Calliphora dux*).

The Hawaiian sheep-maggot fly was first collected by the writer on the island of Molokai. It was forwarded to Washington for determination, and Mr. D. W. Coquillett, of the Bureau of Entomology, identified it as the above-named species, which had not hitherto been recorded from the Territory of Hawaii and is here for the first time known as an animal parasite. No reference can be found in the literature of animal parasitism, to a similar case of a practically obscure species, supposedly infesting only dead animal tissue, suddenly adapting itself to living animals with such serious results. The outbreaks that have thus far come to our notice are sufficient to place the species in the front rank of the pests with which stockmen in Hawaii will have to deal, especially in sheep raising.

The fly has probably been in this Territory for a comparatively long time, and, while details have not yet been secured, enough information is at hand to show that sporadic cases of "blown" sheep have occurred in past years without epidemics resulting from them. An understanding of our own species has been extended by references to similar injury to sheep from different, though related, species in the British Isles and Australia. The problem is far from being solved, and demands extended and detailed study before definite conclusions can be reached.

The fly itself can be recognized as the species with bluish green metallic coloration which breeds wherever decaying flesh is left exposed. On the ranches, where it occurs, it is always attracted in numbers when animals are slaughtered. The fly will "blow," that is, deposit its eggs, on any exposed meat or in any wound, but preferably when the wound has become foul. Its development as a parasite of sheep in this Territory began by the flies blowing the scars from sheep scab which had been irritated to bleeding by the horn fly. The attack of the blow fly, combined with the sheep-scab and horn fly injury, in some instances resulted in the death of the animal; and from the carcasses of the dead sheep innumerable flies developed. From this source the fly became epidemic and began to blow not only the sheep-scab wounds, but also dead wool or wool fouled in any manner, especially on sheep or lambs suffering with scours.

When the eggs are deposited on wool, the resulting maggots, which appear within twenty-four hours, work down through the wool to the body. They do not attempt to penetrate the unbroken skin, as do the screw-worm maggots, but work in a constantly moving, intermingled mass over the surface, causing irritation, which brings about inflammation and ulceration, on the products of which the larvae feed. Later, the wool drops off, leaving a festering ulcer that is constantly being reblown, while masses of eggs are also being deposited in the filthy wool surrounding the sore. Such an infestation, of one week's standing, will contain maggots in all stages of development, as well as unhatched eggs. When the skin is completely destroyed, the maggots penetrate with ease in all directions under the skin, forming fistulas and sinuses, and the animal dies from septicemia or from exhaustion.

As the maggots mature, they drop to the ground and pupate in the soil. The life cycle does not extend over more than three weeks and the larvae or maggots develop in less than ten days.

No remedy has yet been found that in one application will kill the maggots, disinfect the wound, and prevent reinfection. The present treatment is a dual one. All loose and foul wool is removed and destroyed and the wound and surrounding skin are treated with a mixture of chloroform and kerosene oil in the proportion of 1 to 10. This dislodges and kills all the maggots. An application is then made, with a brush, of a mixture of flowers of sulphur and Stockholm tar in equal proportions by measure, to which has been added a small amount of sperm oil (1 quart to 5 gallons of the mixture) to give elasticity to the resulting crust. The wound heals well under the crust, which not only protects it from being reblown, but also from attacks by the horn fly. With the exception of aggravated cases, one treatment is sufficient, but the treated animals must be watched closely, as they are likely to bite off the crust on account of the itching which accompanies the healing process.

By far the most important measure in dealing with an epidemic of maggot flies is to locate the affected animals, and this is, to say the least, extremely difficult when the animals are on the open range or in large pastures, and with sheep which are not accustomed to being herded it is impossible to get near enough to them without rounding up the entire lot and examining them in a corral. On the open range or in pastures containing perhaps 10,000 acres, only the worst cases can be seen, when they lag behind the herd from weakness. Such animals may just as well be killed and buried on the spot, in which case care should be taken to bury them deep enough to exclude the possibility of newly hatched maggots working down to them, as the stench which rises to the surface from a carcass in a shallow grave will cause numerous flies to deposit their eggs on top of it. The writer has seen such a grave, from which the egg masses could be scooped up in double handfuls. This fully illustrates the necessity for disposing effectively of all dead animals, especially during an epidemic.

Equal care must be taken to destroy all eggs and maggots in pens where affected animals are being tagged or treated. We have seen the ground in such a pen completely covered with newly hatched flies, sitting so close together as to lend a greenish sheen to the surface. Two or three weeks before this observation was made, a number of sheep had been treated there for maggots. The affected animals should be treated and sheared on a piece of canvas or a wagon-sheet and the rubbish collected and burned.

BEE KEEPING.

The year has been marked by a decided impetus to the bee-keeping industry. The last estimate of the annual crop was 600 tons. This season's crop will amount to nearly 1,000 tons. Two reasons can be assigned for this increase, (1) a normal flow from the algaroba, and (2) the extension of the industry, i. e., increase of the number of colonies and establishment of new locations. The number of colonies at present in the Territory is not far below 20,000. Two companies have begun operations on the Island of Hawaii (the largest island of the group) and one concern at least on account of the many desirable locations available is in a position to increase rapidly. On the Island of Kauai the greatest extension of the industry has occurred and two corporations are well established. The Island of Oahu is practically the only island where the available territory is occupied, with the possible exception of the lee side and west end of the Island of Molokai. One corporation is now well established on the Island of Maui and an increase has been made on this island with the opportunity for still further increase. The honey and wax crop of the islands is worth in round numbers $100,000, and the next few years will see the production increased by at least one-half.

A survey of the available bee plants, apiaries, and locations for apiaries, which is under way, has been completed for the Island of Molokai. Several trees and plants of value as bee pasturage have been introduced, and some of these are now established. In regard to the introduction of plants, the general policy has been that only plants possessing a dual value will be considered, that is, plants which not only produce nectar but are of value as forage or timber. This will obviate the danger of establishing in the Territory any plant which might become noxious. The lantana is a great object lesson in this respect. The following is a list of the plants that produce nectar in Hawaii:

THE SOURCE OF HONEY IN THE HAWAIIAN ISLANDS.

FOREST TREES.

Algaroba, keawe (*Prosopis juliflora*). This tree is the most abundant and important nectar-producing plant in the Hawaiian Islands. The principal apiaries are situated along the leeward coasts in the shelter of the algaroba forests. The honey is of a high grade.

Texas mesquite (*Prosopis glandulosa*) was found growing in the dooryard of Mr. C. C. Conradt, Pukoo, Island of Molokai. Seedlings are being propagated at the station. This tree was introduced from Texas by Mr. Conradt several years ago.

Ohia lehua (*Metrosideros polymorpha*) produces a particularly high grade of honey. Locations for apiaries as a rule are somewhat inaccessible. One location on the Island of Molokai is within the ohia lehua belt.

Various species of acacia (black wattle, koa, etc.) occur in mountainous districts.

Various species of eucalyptus are found in mountainous districts.

Wiliwili (*Erythrina monosperma*) occurs in gulches on Molokai and Oahu.

Rose-apple (*Eugenia jambosa*) and Mamani (*Sophora chrysophylla*) are found in higher forest belts.

Catalpa (*Catalpa speciosa* and *C. bignonioides*) was introduced by Mr. Jared G. Smith, April, 1902, from the Missouri Botanical Gardens. The seeds were distributed to the Makawao district and Puunene on Maui; to the Moanalua Gardens on Oahu; to Makaweli on Kauai, and to Hamakua and Kohala districts on Hawaii. No reports are on file at this station as to the results of this introduction.

Logwood (*Haematoxylon campechianum*) is found in dooryards. Two trees are growing in the grounds of Oahu College and one in the grounds of Lunalilo Home, Honolulu. Seedlings are now being propagated at the station. The honey produced by bees from this tree is reported to be the finest table honey in the world. The propagation and distribution of the logwood throughout the Territory would be of great value to bee keepers, and the wood furnishes the logwood dye of commerce.

The black mangrove of Florida was introduced by Mr. Jared G. Smith from Southern Florida, for the purpose of holding the mud flats along the coast of Molokai near Kaunakakai from washing. The introduction was made several years ago and the trees are now well established at the above mentioned place. The tree is a valuable honey plant. The station has also secured the Philippine mangrove, a tree suitable for similar locations but possessing greater value as a timber tree.

FRUIT TREES.

Various citrus species (orange, lemon and lime), avocado (*Persea gratissima*), banana (*Musa* spp.), guava (*Psidium* spp.), loquat (*Eriobotrya japonica*), and tamarind (*Tamarindus indica*).

PASTURE PLANTS.

California bur clover (*Medicago denticulata*) was introduced on Maui in 1882 by Mr. C. R. Blacow, and is now found generally on the ranches of the islands.

Carpet grass (*Lippia repens*) is growing on grounds of the station.

Alfilaria or filaree (*Erodium cicutarium* and *E. moschatum*) seeds were introduced in California hay, and has become established on upland pastures on Hawaii and Molokai.

White clover (*Trifolium repens*) is found on Haleakala and Makawao pastures, Maui.

CROP PLANTS.

Sisal (*Agave sisalana*).

Various species of cucurbits (melons, squashes, pumpkins, cucumbers, etc.).

FORAGE PLANTS.

Alfalfa, several varieties.

Lupine, blue and yellow, is occasionally used as green-manure plant on sugar plantations.

Tangier pea (*Lathyrus tingitanus*) is growing at Haiku, Maui.

Sanfoin (*Onobrychis sativa*) is a forage plant introduced by Jared G. Smith in 1904. The seed was distributed to ranches.

ORNAMENTAL PLANTS.

Palms, particularly the royal and cocoanut.

Poppy, a horticultural form of *Romneya coulteri* is found in gardens in Honolulu.

Chinese ink-berry (*Cestrum diurnum*), *Thevetia neriifolia* and vines (*Ipomoea* spp.).

WEEDS.

Lantana, two species.

California sages (*Salvia*) were introduced by Hawaiian Bee Keepers' Association in 1907, but are not as yet established. They are suitable for waste, arid lands, are the most important honey plant in California and are also valuable as forage plants.

Ilima (*Sida* spp.), oi (*Verbena bonariensis*), pili grass (*Heteropogon contortus*), Spanish needle or lauki (*Bidens pilosa*), puakala (*Argemone mexicana*), alii (*Dodonaea viscosa spathulata*), and hila hila (undetermined). Other weeds are *Waltheria americana*, *Ipomoea pes-caprae* (vine along seacoasts), and *Malvastrum tricuspidatum*.

INSECT HONEYDEW.

The most important source of honey in the Hawaiian Islands, aside from the amount elaborated from the nectar of the flowers of algaroba, is honeydew derived from the secretion deposited on the leaves of sugar cane by the sugar cane leaf hopper (*Perkinsiella saccharicida*). Insect honeydew is derived, to a limited extent, also from the secretions of the sugar cane aphis (*Aphis sacchari*).

Further, in Hawaii, as in other tropical countries, plant lice, scale insects, and related families are abundant, and some insect honeydew is to be found on plants in almost any locality.

PLANT HONEYDEW.

While no great amount of this product is gathered and stored by honeybees in Hawaii, bees have been observed locally collecting the plant honeydew secreted by the extra floral nectaries on the leaves of hau trees (*Paritium tiliaceum*). The planting of cotton on a large scale will mean an increase in plant honeydew pasturage, since similar glands are found on the bracts of the bolls and the midrib of the leaves of the cotton plant.

A bulletin on Hawaiian Honey was published during the year. This bulletin is available for distribution and presents the character and source of the honeys of the islands in detail.

An event of great importance to the bee-keeping interests in Hawaii was an extended visit to the islands by Dr. E. F. Phillips, in charge of apiculture in the Bureau of Entomology. Dr. Phillips arrived in the latter part of February, 1908, and remained until April 1, visiting during this time all the principal apiaries on the islands of Oahu, Kauai, Molokai, Maui and Hawaii. The Hawaiian Bee Keepers' Association has taken an active part in the introduction of bee plants and in securing legislation pertaining to the importation and inspection of honeybees and honey.

PINEAPPLE INSECTS.

In 1904 the writer published a report on the pineapple scale (*Diaspis bromeliae*). With the great increase in the acreage devoted to pineapple culture, the mealy-bug (*Pseudococcus citri*) has become equally as serious as the scale if not more so. The scale is primarily leaf-feeding, while the mealy-bug infests the roots, the basal portions of the leaves, the center of the plant, and is particularly abundant at the base of the fruit. Aside from the injury to the plant, the mealy-bug injures the fruit directly by its feeding and indirectly by acting as an agent in the spread of the pineapple rot. The resulting injury blemishes the fruit, making it unfit for the fresh-fruit trade, and greatly impairs its keeping qualities during shipment.

Because of the large area of land now in pineapples it is important to control these species, both from the standpoint of increasing the production and from that of producing fresh fruit for shipment. The modern market will not accept inferior or infested fruit. The Hawaiian product is a superior fruit and the growers have undertaken vigorous measures to suppress insect pests.

During the last season it has been demonstrated that the scale and mealy-bug can be controlled in the field and that clean shipments of fruit are possible by proper methods of fumigation. It is sufficient to say that the fruit has passed inspection under the rigid horticultural quarantine law in operation at the port of San Francisco.

Trial fumigation of plants before setting them in the field indicates that plants will not stand as large a dosage of cyanid gas as fruit for shipment. In the case of fruit for shipment it is possible to use a dosage that will kill all forms of both the pineapple scale and the pineapple mealy-bug without injuring the fruit. Tests demonstrate that the plants are more susceptible to injury, and until the point of safety to which the dose can be increased is determined, the following dosage for the fumigation of plants is recommended: For every 100 cubic feet of air space use 1 ounce by weight of potassium cyanid, 2 fluid ounces of sulphuric acid, and 4 fluid ounces of water. The time required is one and one-half hours. A relatively smaller dose, with longer exposure, is less injurious than a larger dose and shorter exposure. Economy of labor can be obtained by increasing the capacity of the fumigation outfit in proportion to the length of time. With the above dose nearly all of the active forms are killed. The individuals developing from the immature forms must be treated later in the field.

For field treatment, an emulsion of kerosene is recommended for the scale, and tobacco dust for the mealy-bug. The kerosene emulsion is described in Press Bulletin No. 10. The tobacco-dust treatment consists in applying a small handful in the center of the plant, care being taken not to use the dust when the bud is forming or while the plant is in flower. Tobacco dust has been placed on the market in Honolulu for less than $45.00 per ton.

For fruit for shipment a larger dosage may be used, and 1½ ounces of potassium cyanid is recommended to every 100 cubic feet of air space, the proportion and time being the same as given for fumigating plants.

Fumigation work is being successfully done under canvas treated with oil or paint and in special air-tight rooms. The growers have the work well in hand and the insects affecting pineapples in Hawaii present no serious obstacles in the production and marketing of the fruit.

Acknowledgment is made of the helpful coöperation and suggestions of Mr. E. M. Ehrhorn, horticultural inspector at the port of San Francisco, in the work of determining the proper dosage for the fumigation of fruit for shipment.

MOSQUITOES.

The investigations relating to mosquitoes have been brought to a close. The important facts concerning the species of mosquitoes found in Hawaii, their breeding places and habits, and measures for their suppression, have been worked out and the information given to the public in bulletin form and in the reports of the station. The control of mosquitoes has been assumed by the Territorial Board of Health. The inspectors of the Board are doing very efficient work, in consideration of the fact that no funds for the work are available and consequently no addition to the force possible.

On August 3, 1906, regulations were adopted for mosquito prevention and abatement and made a part of the rules and regulations of the Board of Health of the Territory of Hawaii.

A REVISED LIST OF THE INJURIOUS INSECTS OF HAWAII.[*]

The list of injurious insects of Hawaii was begun in the report of the entomologist for the fiscal year 1904. The annual reports of the station have appeared in widely separated publications of the Department and some of the early reports are not now available. On this account and for the further reason that many additional determinations have been made and that some corrections are necessary it is deemed advisable to give herewith the complete list with references to the former reports. Additions to the list are given to bring the report down to date.

CROPS.

SUGAR.

The sugar-cane leafhopper (*Perkinsiella saccharicida*).[a]
The sugar-cane borer (*Sphenophorus obscurus*).[a]
The sugar-cane leaf-roller (*Omiodes accepta*).[a]
The sugar-cane mealy-bug (*Pseudococcus calceolariae*).[a]
The sugar-cane aphis (*Aphis sacchari*).[c]
Mole cricket (*Gryllotalpa africana*).[a]
Cockroach (*Eleutheroda dytiscoides*).[a]
Fuller's rose beetle (*Aramigus fulleri*).[a]
Longhorned grasshopper (*Xiphidium varipenne*).[c]

RICE.

The rice weevil (*Calandra oryza*).[c]
The Angoumois grain moth (*Sitotroga cerealella*).[d]
Mole cricket (*Gryllotalpa africana*).[c]
Longhorned grasshopper (*Xiphidium varipenne*).[c]
Shorthorned grasshopper (*Oxya velox*).[c]
The rust-red flour-beetle (*Tribolium ferrugineum*).[c]
The cadelle (*Tenebrioides mauritanica*).[c]
A beetle (*Rhizopertha pusilla*).[d]

COFFEE.

Scale insect (*Pulvinaria psidii*).[a]
Leafhopper (*Siphanta acuta*).[a]
Aphid (undetermined).[a]

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[*] The letters after the names in the list refer to former reports as follows:

[a] Ann. Rept. Hawaii Expt. Sta. 1904, U. S. Dept. Agr., Office Expt. Sta. Rpt. 1904, Washington, 1905, pp. 372-379.

[b] Report on Arigultural Investigations in Hawaii 1905., U. S. Dept. Agri. Office Exp. Stas. Bul. 170 Washington 1906, pp. 38-59.

[c] Ann. Rpt, Hawaii Exp. Sta. 1906, Washington, 1907, pp 18-32.

[d] Ann. Rpt. Hawaii Exp. Sta. 1907, Washington, 1908, pp. 25-51.

[e] Rpt. Governor Ter. of Hawaii, 1902, p. 35.

TARO.

Mole cricket (*Gryllotalpa africana*).[b]
Aphid (undetermined.)[b]

SISAL.

A weevil (*Pseudolus longulus*).[b]
Mealy-bug (*Pseudococcus* sp. undetermined).[b]
The black scale (*Saissetia oleae*).[b]

TOBACCO.

Tobacco leaf-miner (*Phthorimaea operculella*).[a]
Tobacco flea-beetle (*Epitrix parvula*).[a]
Tobacco hornworm (*Phlegethontius quinquemaculata*).[b]
Cigarette beetle (*Lasioderma serricorne*).[b]
Black cutworm (*Agrotis ypsilon*).[a]
Bollworm (*Heliothis obsoleta*).[a]
Japanese beetle (*Adoretus umbrosus tenuimaculatus*).

COTTON.

Bollworm (*Heliothis obsoleta*). This insect is the widely known bollworm of cotton of the southern United States. The writer observed its work on the young buds of tobacco in 1905, and in restricted areas its work was serious. It is periodically injurious to the ears of corn. The insect has not been observed on cotton nor is the species at all common. Since many of the food plants of the worm are common it would seem that the insect is held in check by some natural factor, probably tachinid flies. It is, however, an insect whose presence in the cotton fields it is well to anticipate.

Japanese beetle (*Adoretus umbrosus tenuimaculatus*). The Japanese beetle has been observed to skeletonize the leaves of the cotton plant in many of the plantings of cotton that have been made on a small scale in isolated places. The behavior of the beetle in fields of considerable area can not be predicted, but as it is a leaf feeder, its injury in the first place will not be as serious as that of forms attacking the boll; in the second place, it can be controlled by spraying with an arsenical poison. It is of interest to note that the Japanese beetle showed a decided preference for the Chinese variety of cotton—in comparison with the Caravonica—in the plantings made at the station during the year.

Small bollworm (*Gelechia gossypiella*). This species is noted by Dr. R. C. L. Perkins in 1902 as "Gelechiid (undetermined) attacking cotton bolls"[c] and recorded by Lord Walsingham under the above determination from Hawaii in Fauna Hawaiiensis[b] with the description and extended notes on the occurrence of the species in India and Japan. The moth was bred by the writer from infested cotton bolls received from Holualoa, Kona, Island of Hawaii, in 1905, and is common about Honolulu. A detailed study has been begun of the life-history of this moth and this with the feeding habits of the worm and possible means of suppression on a field basis will form the important part of the investigations to be undertaken by the assistant entomologist during the year.

A weevil (*Araeocerus fasciculatus*). This weevil was bred from cotton bolls received from Hookena, South Kona, Island of Hawaii, in December, 1905. Determined by Mr. E. A. Schwarz of the Bureau of Entomology.

Mealy-bug (*Pseudococcus filamentosus*). Very abundant at times on the young stems and bolls. Fed upon to a great extent by the ladybird beetle (*Cryptolaemus montrouzieri*).

Cotton aphis (*Aphis gossypii*). Determined by Mr. Th. Pergande of the Bureau of Entomology. Fed upon by larva of syrphus fly (*Xanthogramma grandicornis*) and predaceous plant-bug (*Zelus peregrinum*).

CASSAVA.

A snout-beetle (*Pseudolus longulus*).[b]
A longhorned beetle (*Lagocheirus araneiformis*).[b]

SWEET POTATO.

Sweet-potato weevil (*Cylas formicarius*).[d]
Sweet-potato sphinx (*Phlegethontius convolvuli*).[d]
Sweet-potato vine borer (*Omphisa anastomosalis*).[d]
A root maggot (*Pegomya fusciceps*).[d]

CORN.

Corn leaf hopper (*Dicranotropis maidis*).[a]

"Green fly" of corn (undetermined species of aphidid.)[a]

Cutworms (several undetermined species, among them *Agrotis ypsilon*).[a]

CABBAGE.

Cabbage aphis (undetermined, probably *Aphis brassicae*).[a] An internal parasite (*Lysiphlebus testaceipes*) has been bred from this aphis. It forms an important natural check to the aphis here.

A leaf-miner (*Plutella maculipennis*).[b] Parasitized by *Campoletis* (*Limneria*) *tibiator*.

Root maggot (*Pegomya fusciceps*).[d]

The cabbage butterfly (*Pontia rapae*).[a]

Cutworms (undetermined).[a]

MELONS.

The melon fly (*Dacus cucurbitae*)[a], illus. art.[d] It is believed that at the present price of melons it would pay to grow muskmelons at least, under cover, fertilizing the flowers by a colony of bees.

Aphidid (undetermined). Very abundant on young vines.

Stem borer (*Apomecyna pertigera*) larva of a Cerambycid. Taken in numbers from stems of watermelons at Makaha, island of Oahu. Determined by Mr. E. A. Schwarz of the Bureau of Entomology.

PINEAPPLE.

Pineapple scale (*Diaspis bromeliae*).[a]

Common mealy-bug (*Pseudococcus citri*).[d]

The pomace fly (*Drosophila ampelophila*).[d]

Red spider (*Stigmaeus floridanus*), Banks. Taken from pineapple on station grounds during the year.

CITRUS.

Purple scale (*Lepidosaphes beckii*).[a] [b]

Fluted scale (*Icerya purchasi*).[a]

Orange aphis (*Myzus citricidus*).[a] [c]

Scale (*Parlatoria ziziphus*).[d]

Leafhopper (*Siphanta acuta*).[a]

Common mealy-bug (*Pseudococcus citri*).[d]

Bark beetle (*Stephanoderes* sp.)[b]

Florida red scale (*Chrysomphalus aonidum*).[c]

Scale (*Pulvinaria psidii*).[c]

Mealy-bug (*Pseudococcus filamentosus*).[c]

Scale (*Coccus viridis*).[c]

Fuller's rose beetle (*Aramigus fulleri*). Injurious to limes on the island of Molokai during the summer of 1907.

Scale (*Coccus punctuliferus*). Collected from lime at Makaha, island of Oahu. Determined by Mr. Sanders of the Bureau of Entomology.

Cockroach (*Eleutheroda dytiscoides*). Determined by Mr. Caudell of the Bureau of Entomology. Received from Napoopoo, Kona, island of Hawaii. Reported as injurious to lime trees by girdling the branches.

MANGO.

The mango weevil (*Cryptorhynchus mangiferae*).[b]

Torpedo bug (*Siphanta acuta*).[a]

Scale (*Phenacaspis eugeniae*).[b]

The mango scale (*Coccus mangiferae*).[c]

Florida red scale (*Chrysomphalus anonidum*).[c]

Scale (*Trionymus americanus*).[d]

Thrips.[d] Mr. Th. Pergande of the Bureau of Entomology identified the thrips on the mango as *Heliothrips* sp, and says under date of March 3, 1908, that the species is apparently new.

Scale (*Pulvinaria mammeae*). Found also on orange, coffee and ferns. Originally described from Hawaii on the mammee apple (*Mammea americana*). Determined by Mr. J. G. Sanders of the Bureau of Entomology.

BANANA.

The sugar-cane borer (*Sphenophorus obcurus*).[a]
A borer (*Calandra remota*).[a]
The banana leaf-roller (*Omiodes meyricki*).[a] [d]
Florida red scale (*Chrysomphalus aonidum*).[b]
Scale (*Phenacaspis eugeniae*).[b]
Scale (*Saissetia nigra*).[c]

AVOCADO.

Avocado mealy-bug (*Pseudococcus nipae*).[a]
Scale (*Fiorinia fioriniae*).[a]
Scale (*Phenacaspis eugeniae*).[b]
Bark beetle (*Xyleborus immaturus*).[b]

FIG.

Avocado mealy bug (*Pseudococcus nipae*).[a]

Scale (*Saissetia nigra*). Taken from fig in Moanalua Gardens, Honolulu.

GRAPE.

Japanese beetle (*Adoretus umbrosus tenuimaculatus*).[a] [c]
Avocado mealy bug (*Pseudococcus nipae*).[a] [c]
Fuller's rose beetle (*Aramigus fulleri*).[c]
Mealy bug (*Pseudococcus filamentosus*).[c]
Larva of moth (*undetermined*).[c]

APPLE.

Japanese beetle (*Adoretus umbrosus tenuimaculatus*).[d]
Scale (*Pseudaonidia clavigera*).[d]

PEACH.

Fuller's rose beetle (*Aramigus fulleri*). Observed during the year in very destructive numbers on peach on the island of Molokai.

Peach scale (*Aulacaspis pentagona*).[a] Bark beetle, probably an undescribed species. Collected in Nuuanu Valley, Honolulu.

GUAVA.

Avocado mealy-bug (*Pseudococcus nipae*).[a]

Fuller's rose beetle (*Aramigus fulleri*). Feeding to great extent on guava on the islands of Hawaii and Molokai.

MULBERRY.

Avocado mealy-bug (*Pseudococcus nipae*).[c]
Mealy-bug (*Pseudococcus filamentosus*).[c]
Scale (*Saissetia* sp., undetermined).[c]

STRAWBERRY.

A ground beetle (*Ompatrum serratum*).[a]
Japanese beetle (*Adoretus umbrosus tenuimaculatus*. The Japanese beetle is the principal insect injurious to strawberries in Hawaii. The Japanese gardeners control the pest by picking.

SOUR-SOP.

Avocado mealy-bug (*Pseudococcus nipae*).[b]
Scale (*Coccus longulus*).[b]

COCOANUT.

Palm leaf-roller (*Omiodes blackburni*)[d].
Sugar-cane borer (*Sphenophorus obscurus*).[d]
Florida red scale (*Chrysomphalus aonidum*).[d]

ORNAMENTAL PLANTS.

HIBISCUS.

Mealy-bug (*Pseudococcus filamentosus*).[b]
Leaf caterpillar (*Cosmophila sabulifera*).[d]

ROSES.

Japanese beetle (*Adoretus umbrosus tenuimaculatus*).[a]
Rose aphis (*Macrosiphum rosae*).[d]
Rose scale ,*Aulacaspis rosae*).[a]
Fuller's rose beetle (*Aramigus fulleri*).[a]

PALMS.

Sugar-cane borer (*Sphenophorus obscurus*).[a]
Hemispherical scale (*Saissetia hemisphaerica*).[b]
Mealy-bug (*Pseudococcus pseudonipae*).[b]
Scale (*Chrysomphalus dictyospermi*).[b]
Florida red scale (*Chrysomphalus aonidum*).[c]

PEPPER TREE.

Scale (*Saissetia nigra*).[d]
Scale (*Aspidiotus lataniae*).[d]

BAMBOO.

Scale (*Asterolecanium miliaris*).[d]

CROTON.

Scale (*Lepidosaphes pallida*)[b].

IPOMOEA.

Scale (*Coccus hesperidum*). Parasitized by *Coccophagus immaculatus*).[b]

Sweet potato sphinx (*Phlegethontius convolouli* Linn). Collected from vines at the station.

OLEANDER.

Scale insect (*Phenacaspis eugeniae*).[c]

ASPARAGUS.

(*Asparagus sprengeri.*)

Avocado mealy-bug (*Pseudococcus nipae*). Collected during the year on the station grounds.

Scale (*Hemichionaspis minor*). Collected during the year on the station grounds. Determined by Mr. J. M. Sanders, of the Bureau of Entomology.

FOREST TREES

ALGAROBA.

(*Prosopis juliflora.*)

Longhorned beetles (*Cyllene crinicornis* and *Microcantha nutans*).[b]

Large powder beetle (*Bostrichus migrator*).[b]

Small powder beetle (*Sinoxylon conigerum*).[b]

The bean weevil (*Bruchus obtectus*).[b]

Scale insect (*Asterolecanium pustulans*).[d]

BLACK WATTLE.

(*Acacia decurrens.*)

Longhorned beetles (*Cyllene crinicornis*, *Xystrocera globosa*, *Ceresium simplex*, and *Sotenus setiger*).[b]

Weevil (*Bruchus* sp.).[b]

Wireworm (*Chalcolepidius erythroloma*).[b] Probably injurious to roots.

Barkbeetle (*Stephanoderes sp.*).[b]

Leafhopper (*Siphanta acuta*).[b]

Fluted scale (*Icerya purchasi*).[b]

Caterpillar of tineid moth (undetermined).[b] Beneath bark.

CEARA RUBBER.

Scale insects (*Saissetia nigra*, *Saissetia oleae*, and *Aspidiotus cyanophylli*).[c] [d]

Mealy-bug (*Pseudococcus* sp., undetermined).[c]

Barkbeetle (*Xyleborus affinis*).[d]

Snout-beetle (*Pseudolus longulus*).[d]

Wireworm (undetermined Elaterid).[d]

OHIA LEHUA.

(*Metrosideros polymorpha.*)

Fuller's rose beetle (*Aramigus fulleri*). This beetle is a very serious enemy of Ohia in certain districts on the island of Hawaii. Trees were observed in the Kohala mountains that were completely defoliated.

Termite (*Calotermes castaneus*). Taken from living trees in the Kohala mountains, island of Hawaii.

WILD GUAVA.

Barkbeetle (*Xyleborus affinis*).[d]

Scale insect (*Aspidiotus lataniae*).[d]

CATTLE.

Hornfly (*Haematobia serrata*).[a] [d]

Warble flies (*Hypoderma bovis* and *H. lineata*).[d]

SHEEP.

Sheep-maggot fly (*Calliphora dux*).[d]

Bluebottle flies (*Lucilia sericata* and *L. caesar*).[d]

Flesh flies (*Sarcophaga barbata* and *S. pallinervis*).[d]

Sheep head-maggot fly (*Oestrus ovis*).[d] This sheep head-maggot was taken from the head of a lamb on Molokai during the year and adult flies reared from the larvae. As previously stated, the species is recorded by Grimshaw from the island of Kauai in 1901. Its presence on the island of Molokai indicates that this persistent pest to sheep is established in the islands.

Horn fly (*Haematobia serrata*).[d]

HORSES.

Stable fly (*Stomoxys calcitrans*).[d]

Horse botflies (*Gastrophilus equi* and *G. nasalis*).[d]

"Night" mosquito (*Culex cubensis*).[d]

POULTRY.

The turkey louse (*Goniodes stylifer*). Collected on the island of Molokai during the year.

The chicken louse (undetermined).[d]

The chicken mite (undetermined).[d]

The "night" mosquito (*Culex cubensis*).[d]

HOGS.

The hog louse (*Haematopinus urius*). Received from Kamehameha School, Honolulu, during the year. Collected by F. G. Krauss.

DOGS.

The dog flea (*Ctenocephalus canis*).[d]

The dog tick (*Rhipicephalus sanguineus*).[d]

The "night" mosquito (*Culex cubensis*).[d] The mosquitoes—and especially the "night" mosquito—annoy all domestic animals, this annoyance being particularly noticeable in the case of horses, young poultry and dogs. It is believed, further, that this species is the transmitting agent of the disease of dogs known as "heartworm."

HOUSEHOLD INSECTS.

Mosquitoes (*Culex cubensis, Stegomyia calopus* (yellow fever mosquito), and *S. scutellaris*).[a]

Cockroaches (*Periplaneta americana* and *P. australasiae*).[a]

The typhoid or house fly (*Musca domestica*).[a]

Ants. Several species, undetermined, among them the cosmopolitan red ant.

Termite (*Calotermes marginipennis*).[a]

Bedbug (*Cimex lectularius*).

The dog flea (*Ctenocephalus canis*). (See under Live Stock).

Silverfish (*Lepisma* sp., undetermined).[a]

Carpenter bee (*Xylocopa aeneipennis*).[a]

Mud dauber (*Pelopoeus cementarius*).[a]

Clothes moth, undetermined.[a]

STORED PRODUCTS.

Rice weevil, (*Calandra oryza*).[a]

Cigarette beetle (*Lasioderma serricorne*).[a] [b]

Bean weevil (*Bruchus obtectus*).[a]

Rust-red flour beetle (*Tribolium ferrugineum*).[a]

Angoumois grain moth (*Sitotroga cerealella*). Common in stored rice.

Ham and cheese maggot (*Piophila casei*).[d]

Cadelle (*Tenebrioides mauritanica*).[d]

Weevil (*Calandra linearis*).[d]

Bamboo beetle (*Dinoderus minutus*).[a]

Bone-meal beetle (*Dermestes cadaverinus*).[b]

Beetles (*Silvanus mercator* and *Araeocerus fasciculatus*).[d]

Beetle (*Lophocateres pusilla*). Bred from rolled barley during the year.

Book louse (*Troctes divinatorius*). Common pest of dried specimens in museum collections, books, and taken during the year from rice flour.

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(Continued from Report of the Entomologist, Annual Report of the Hawaii Agricultural Experiment Station for 1907, pp. 48-51.)

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REPORT OF THE HORTICULTURIST.

By J. Edgar Higgins.

SHIPPING TROPICAL FRUITS.

The chief work of the year in horticulture was in fruit shipping investigations. The fruits dealt with were pineapple, avocado, papaya, and banana, all of these being shipped to San Francisco. It was demonstrated that pineapples and avocados can be safely shipped as far as Chicago in refrigeration. This experimental shipment of a single carload was followed by two commercial shipments on the part of pineapple growers during the summer of 1908. A carload was sent to Denver and another to Chicago. The results of the experiments of the year 1907 were published in Press Bulletin 21 of the station and details need not be entered into in this report.

THE ORCHARDS.

TILLAGE AND IRRIGATION.

By a rearrangement of water pipes in the orchards tillage and irrigation have been facilitated. These pipes have been laid parallel to the rows of trees, so as not to interfere with tillage. Where possible, irrigation is practiced by the furrow system. A disk harrow is in frequent use and has been found a most efficient implement for maintaining the proper condition in the surface soil. The orchards are now in a more flourishing condition than at any time since they were planted.

COVER CROPS.

In an orchard of tropical fruits cover crops are not less important than in orchard work under temperate zone conditions. In some respects the need here is greater. The rapidity of oxidation of humus necessitates a frequent renewal, and an abundant supply is the more necessary since evaporation proceeds so rapidly. The torrential rains of the wet season render cover crops essential on steep grades to prevent the washing away of the soil. To these benefits will be added a gain in nitrogen if legumes are used.

The best time for sowing a cover crop is at the close of the dry season, as soon as there is sufficient mosture to give the crop a good start. In the months following there will be enough water to supply the needs of the trees and also the cover crop.

The latter may be plowed under just before the close of the wet season. If deep plowing is done after all rains are over, it will result in the loss of much moisture which might have been conserved.

There is one factor in the use of cover crops in the tropics which does not exist in temperate zone conditions. In temperate climates, most trees are dormant in winter, whereas in the tropics the rainy season brings growth even though it come during the coolest portion of the year. For this reason it may be well not to allow the cover crops to come too close to the trees. In the trials which have been made at this station the plants have not been permitted nearer than 5 feet from the trees. This space has been tilled with cultivators.

Many problems connected with the use of cover crops in Hawaii will have to be worked out under local conditions. The station has tested three promising legumes during the year. These were the cowpea (*Vigna catjang*), pigeon pea (*Cajanus indicus*), and jack bean (*Canavalia ensiformis*). Analyses have been made of these, as will be observed by reference to the Report of the assistant chemist.

The cowpea has made the quickest and most luxuriant growth, rapidly covering the ground and reaching maturity much earlier than any of the others. This plant is also recognized as having excellent feeding value either as hay or in the green form. If fed to stock and if the manure is properly cared for, and returned to the land, it is estimated that about 75 per cent of the nitrogen in the crop will be saved. One objection to the cowpea is its susceptibility to the attacks of aphis. These insects did no serious injury to the past year's crop, but at times have been very destructive.

The pigeon pea requires a much longer time to come to maturity. It makes an upright and spreading growth and is difficult to plow under when it has become full grown. If planted far enough apart to develop fully, the pigeon pea becomes too woody for a cover crop. If planted closely, the falling of the dead leaves makes a complete covering for the soil. The leaves of this plant are said to be useful as fodder. The seeds when nearly full grown may be used as a vegetable like green peas, which they closely resemble. The ripened seeds are also much used in the Tropics. The plant appears to be free from serious insect attacks. The jack bean is a plant of lower growth and although it is less rambling than the cowpea, it makes a good cover. It is quite free from insects.

ORCHARD INSECTS.

The chief insects which have required control on the orchard trees have been scales, mealy bugs and aphis. Kerosene emulsion, in the proportion of 1 part of stock solution to 14 parts of water, was used at the suggestion of the entomologist. This has been found to hold the insects in check and has caused no leaf injury, although used under all conditions of weather.

Another means of reducing the injury due to mealy bugs and aphis has been to apply a tanglefoot mixture to the trunks of the trees, thus arresting the passage of ants.

THE CITRUS ORCHARD.

In December, 1906, a small orchard of seedling citrus trees was planted. The first experinmental use of this is to make a test of the adaptability of different stocks, including rough lemon, shaddock (from Hawaiian grown seed), sweet orange, and the pomelo (from California seed). The soil is rather a light loam on a hill slope which is well drained at all times and in summer tends to be dry. In vigor of growth the different species have stood in the order named above. The rough lemon made a very strong growth, far excelling all the other stocks. This of course is only one feature of its character as a stock upon which to bud improved varieties of citrus. The budding of these stocks has begun, the method of trial being to put in each variety in a single tree of every row, thus making the row of a variety run at right angels to the rows of stocks.

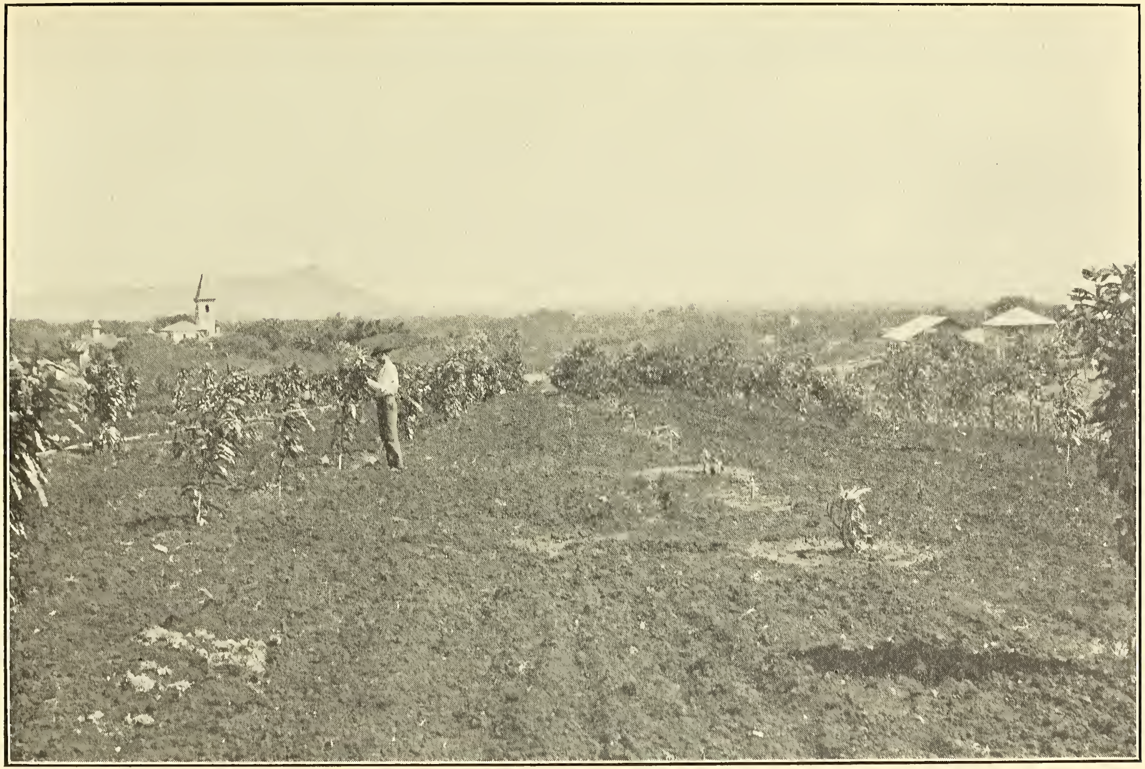
BANANAS.

The varieties of bananas which have occupied a part of the land near the laboratories were moved in March to the bottom of a gulch at a higher elevation. This change was made for several reasons. The bananas were occupying too much of the land near the laboratories that was needed for experiments requiring closer observation. The locality was also unfavorable for bananas, being unprotected from the wind. In the new location there is a greater rainfall, and protection from wind is afforded by the adjoining forest.

The requests for offsets, particularly of the Hawaiian varieties, have been so numerous that the stock has been constantly reduced and the most successful fruiting has been prevented. To avoid a repetition of this and to have offsets available, a banana nursery has been planted from which the different varieties can be drawn at times when the removal of offsets from the fruiting plants would be injurious. This nursery consists of large and well fertilized trenches in which offsets are planted closer than would be desirable for fruiting plants.

The following list of forty-three names includes the varieties of bananas now growing on the station lands: Chamaluco, Guaran or Gigante, Colorado or Marado, Colorado Blanco or Marado Blanco, Congo, Enano, Manzano, Platano Harton, Hua Moa, Lahi, Puhi, Ekiula, Moa, Platano Enano, Enano Doble, Datyl or Rosa, Cinerea, Congo Colorado or Congo Marado, Dominico, Pisang Sereh, Gruindy, Pisang Palembang, Pisang

PLATE II.



GENERAL VIEW OF MANGO AND AVOCADO ORCHARD.
Mango trees in foreground, Avocados beyond. The mango trees in the centre row which have been cut off have been budded.

Kelat, Apple, Hamakua, Malai-ula, Pisang Mass, Johnson (Santa Domingo) Macho, The Tunis, Manai-ula, Paapu, Ice Cream, Hua Alua, Red Cuban, Brazilian, Largo, Bluefields, Cavendishii from the Canary Islands, Chinese, Custard, Eleele, Lele.

It is probable that a few of the above names are synonyms. We are indebted to the Porto Rico Experiment Station for many of the introduced varieties. The Hawaiian varieties have been collected from different parts of the Territory, through the courtesy of numerous friends of the station. Many of these native varieties are quite out of their natural element on the Island of Oahu and none attain their greatest perfection here. Greater humidity of soil and atmosphere and the freedom from winds afforded by their native haunts render their growth and fruiting more luxuriant.

MANGOES.

BUDDING.

Experiments have been made in the budding of mangoes, with some failures and some very gratifying results. In the case of the variety Alphonse, 80 per cent of the buds have grown. The accompanying illustration shows the growth made from one of the buds 7½ months after it was set and 5 months after growth commenced. (See Pl. III, fig. 1.)

It is interesting to note that a period of over 2 months elapsed between the setting of the bud and its starting into growth, and that this was in early spring when vegetation is active. It is a commonly observed fact that the mango tree makes a sudden new growth, and increases the length of its branches several inches in a few days. It then ceases to grow for several weeks, matures its new wood, and prepares a terminal bud for another sudden increase. The budding must be done in the early part of one of these periods of growth. The bud must then await the next growing period before it can start, as would be the case with summer-budded deciduous fruit trees in the Temperate Zone.

The budding was done on seedling trees about 2½ years old. The method used was that of patch-budding.[a] The buds were set a few inches above the ground and when it appeared probable that a union had been effected between bud and stock the latter was cut through about four-fifths of its diameter, the top being allowed to rest on the ground. After the bud had begun to make new growth the top was completely removed.

Where failures occurred, the result of these trials points to an improper condition of bud wood at the time of the operation as the probable cause. While it is important in all budding that the stock should be in active growth so that the bark will separate readily from the wood along the line where new cells are being formed, this is even more important in the mango, where a large-sized piece of bark must be removed, leaving an unbroken surface to receive the new bud. With the mango, activity in the bud-wood is as important as in the stock. It is, therefore, necessary to watch the trees from which buds are to be taken and secure bud-wood at just the right period. This appears to be in the earliest stage of rapid growth and continues for only a few days. At this time they should be taken to the orchard and should be set in such trees as are in similar condition. A large majority of the trees will be found to be making a rapid growth at about the same time.

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[a] See Hawaii Sta. Bul. 12.

The quality of the bark in varieties appears to differ, some being quite brittle and corky. It may be that patch budding will not prove equally well adapted to all sorts of mangoes.

TRANSPLANTING.

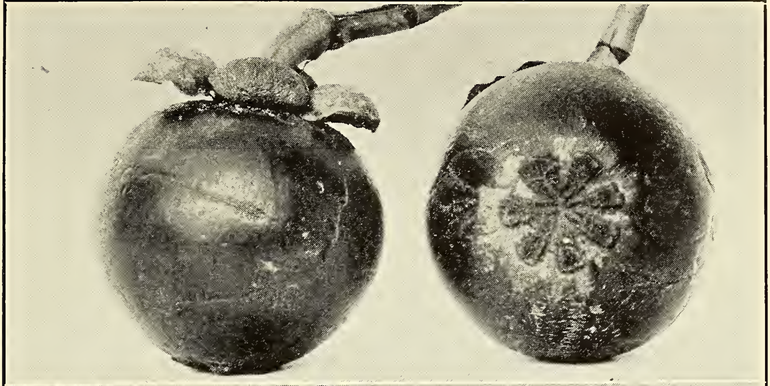
The success with which the transplanting of a mango tree two or more years old can be performed bears an important relation to the methods to be pursued in propagation, and if budding is practiced the degree of success in moving will determine whether the budding must be done on trees in their permanent position in the orchard or may be practiced in nursery row as is done with citrus and deciduous fruit trees.

A few trials were made during the year in the moving of trees about 2½ years old. The test was severe in that it was made during the season of most active growth. All the trees were severely cut back, only the main stem remaining, and of this not more than 18 inches and usually only 6 inches. Some trees were lifted with naked roots and others were balled. None were for a long time out of the ground, and in this respect the test could have been more severe. The results have been quite satisfactory. None of the trees have died and most of them have made a good growth. No difference has been observed between the trees planted with balled roots and those with no soil surrounding them. The trees that were most severely cut back have made the most vigorous growth. While these experiments were not on a sufficiently large scale to justify positive conclusions, their indications are favorable to the handling of the mango as a nursery tree. However, even though this may be quite possible, budding in the orchard may still be more satisfactory.

INARCHING.

Inarching, or grafting by approach, has been practiced to a limited degree. This old and well established method is probably the surest means of propagating fine varieties of mangoes. It is, however, somewhat cumbersome and on a large scale would be expensive.

PLATE III. Fig. 2. Mangosteen, *(Garcinia Mangostana.)*



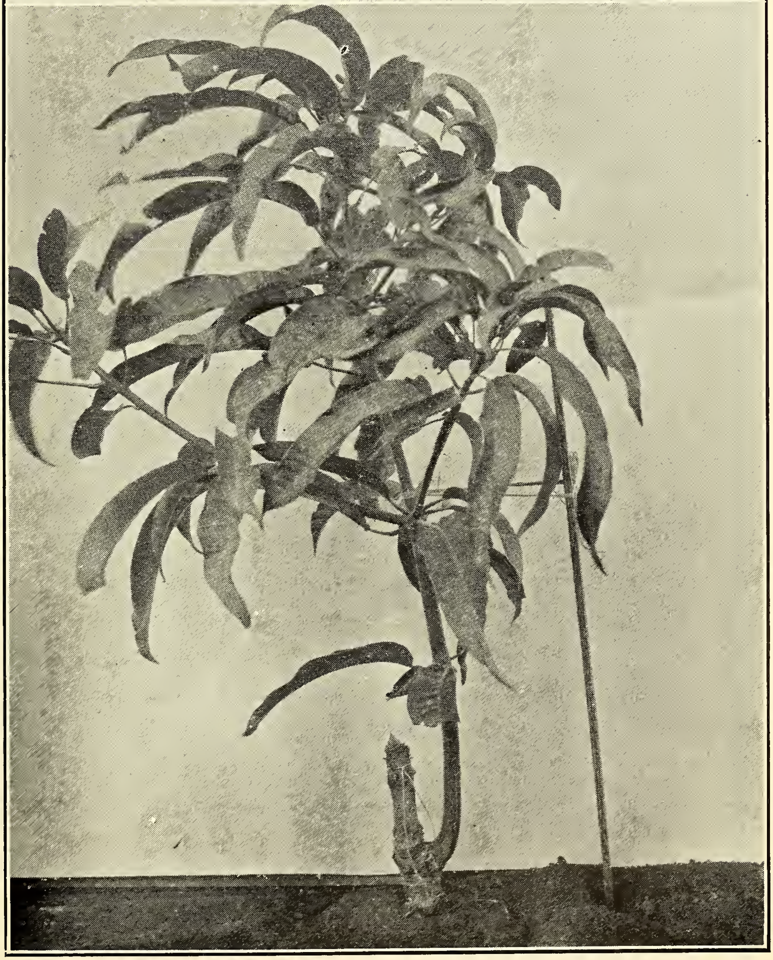


Fig. 1. A budded mango tree 7 1-2 months after the setting of the bud.

SHIPPING BY MAIL.

Shipping young trees by mail has been tried in coöperation with the Office of Seed and Plant Introduction, Bureau of Plant Industry. At different times during the year quite a number of young grafted trees were sent by mail from Washington, D. C., to Honolulu. These were very carefully packed and so far as the moisture of the roots on arrival was concerned, the condition was perfect. The losses, however, were many, due to the withering and dying of immature wood. In most instances also the trees became defoliated in transit or immediately after arrival. The indications were that only trees with firm wood and a dormant terminal bud should be shipped by this method. With such, a good degree of success may be expected.

FLOWERING SEASON.

The season of flowering of the mango in Honolulu has been noted with interest for several years. A record has been kept of the first flowers observed which appeared to be the beginning of a general blooming season, disregarding the few flowers that may appear at almost any time. The record of the beginning of the season has been as follows: January 1 to 10, 1906; December 10 to 12, 1906; November 15 to 20, 1907; and February 15 to 25, 1908. Attention is called to the fact that for three successive years each season of flowering has been nearly one month earlier than in the preceding year. For the mango crop of the summer of 1908 there were two seasons of quite general blooming among the mango trees of Honolulu, the first being in November and the second in February. It will be observed that a period of three months is thus covered which is in marked contrast to the seasons of flowering where climatic conditions are more sharply defined. It will be interesting and instructive to observe the continuation of this cycle.

BORDEAUX MIXTURE FOR BLIGHT.

The use of Bordeaux mixture in the control of mango blight (*Colletotrichum* sp.) has been reported in Bulletin 12, and elsewhere. During the past year some tests were made by Mr. C. J. Hunn, assistant horticulturist and gardener, to determine what strength of the mixture could be used with safety. The following formulas were used:

Formulas for Bordeaux Mixture.

6 lbs. copper sulphate, 6 lbs. lime, and 50 gals. water.
6 lbs. copper sulphate, 5 lbs. lime, and 50 gals. water.
6 lbs. copper sulphate, 4 lbs. lime, and 50 gals. water.
5 lbs. copper sulphate, 5 lbs. lime, and 50 gals. water.

In the case of the third formula considerable leaf injury was observed, and the second was not as satisfactory as the first, more than 5 pounds of lime being necessary to prevent injury from free copper.

PLANT ACQUISITIONS.

Something over 300 numbers have been added to the list of plant acquisitions during the year. Among the more important of these, the following may be mentioned:

"Henequen" (*Agava rigida elongata*). From Missouri Botanic Gardens, through Professor L. H. Dewey, in charge of Fiber Investigations, U. S. Department of Agriculture. The sisal fiber of commerce is derived from plants of the botanical varieties of *Agava rigida*. The present variety is the form commonly cultivated in Yucatan and is said to yield more heavily than the variety *sisalana* but the fiber is of a lower grade. A number of these were distributed and about 400 were planted in nursery row at the station. At first growth was slow, but recently they appear to have become well established.

The parties to whom the distributions were made report that growth has not been nearly so rapid as in the case of the variety *sisalana* under the same conditions. It is however, too early to judge of the merits of the plant as a source of fiber.

PINEAPPLES.

Seven varieties of pineapples of the product of artificial crosses, were received from the Subtropical Laboratory and Garden of the U. S. Department of Agriculture situated at Miami, Florida. The varieties have been described in the 1905 and 1906 Yearbooks of the Department of Agriculture. Those received are as follows: Miami, Deliciosa, Eden, Matthams, Dade, Coquina, and Jensen. Of these, in point of vigor the Eden has ranked first and the Dade second at this station.

ACHOCHA.

Seeds of this Bolivian vegetable were received from Mr. E. M. Ehrhorn, deputy commissioner of horticulture for the State of California. The plants grew vigorously and flowered profusely, but soon after the flowering began, they were completely destroyed by the melon fly.

Sweet sop (*Anona squamosa*), received from Mr. Harry Roberts, Honolulu.

Barleria flava, a yellow flowered ornamental shrub grown from seeds received from the Bureau of Agriculture, Manila.

Sapodilla (*Achras sapota*).

Wampi fruit (*Clausena wampi*). This much esteemed fruit of China and India has been growing in Hawaii in a few gardens for many years, but has never been in general cultivation. The tree is 10 feet to 15 feet in height and produces fruits about ¾ to ⅞ inch in length, and about ½ inch in diameter. It has a straw yellow color and pleasant flavor.

Feijoa sellowiana, a fruit about 2½ inches long and 2 inches thick, with white pulpy flesh said to resemble the guava and the pineapple in flavor. Received from the Couthern California Acclimatization Association.

The cherimoya (*Anona cherimolia*). This highly prized fruit flourishes in a half wild condition in some parts of Hawaii. Quite a large number of seedlings have been grown in the propagating houses for trial at different altitudes on the station tract.

The litchi (*Nephelium litchi*). Two introductions of this species have been made during the year, in each case through the Office of Seed and Plant Introduction. These included three or more of the best Chinese varieties and should make a very valuable acquisition to Hawaiian grown fruits.

Camphor (*Camphora officinalis*). A large number of plants have been grown from seeds received from the Yokohama Nursery Company.

The roselle, variety Victor (*Hibiscus sabdariffa*). A new variety received from the Subtropical Laboratory and Garden, Miami, Florida.

The mangosteen (*Garcinia mangostana*). Pl. III, fig. 2). Two fruits were obtained, in one of which there was a single fertile seed. This has germinated and the seedling is doing well.

The papaya (*Carica papaya*). Four varieties received from Government Stock Gardens, Ceylon.

PLANTS DISTRIBUTED.

The station has continued the practice of distributing seeds and plants of species considered to be worthy of a much more general cultivation and which are not readily obtainable from nurserymen and seedsmen. Among these have been roselle (*Hibiscus sabdariffa*), Bluefields banana, star apple (*Chrysophyllum cainito*) carambola (*Averrhoa carambola*), and many others. At the request of the entomologist, nearly 2,000 mulberry cuttings have been sent to those who are interested in silk production. A record is being kept of all distributions and recipients are expected to report upon the condition of plants entrusted to their care.

MISCELLANEOUS.

Much needed assistance in horticultural work has been provided by the appointment of Mr. Chester J. Hunn to the position of assistant horticulturist and gardener. Mr. Hunn arrived in Honolulu in February, 1908, and began work at once.

The deciduous plantings at the Parker ranch on Hawaii, which were referred to in the last annual report, were visited in March, 1908. At this time all trees requiring it were pruned. The apple and peach trees had made a remarkably vigorous growth at 4,000 feet altitude, and some varieties of peaches were heavily set with fruit buds. The pears, cherries, and apricots had not done so well. At the other orchards the apples and peaches had grown satisfactorily, but not so rapidly as at Waiki, which is at 4,000 to 5,000 feet altitude. The differences, however, appear to be due to other causes than altitude. The soil, situation, and climate at Waiki seem particularly well adapted to the growth of apple and peach trees. It is too early yet to speak of their fruiting and the relation of the flowering season to late frosts.

The greatest hindrances are insects, chief among these being climbing cutworms and Fuller's rose beetle, locally known as "Olinda bug." As a result of these insect attacks a large percentage of the dormant buds was destroyed and the bark from the end of the twigs was eaten. In some instances fully three-quarters of the season's growth was completely stripped. Tree Tanglefoot has since been tried as a means of preventing these injuries, but no reports of its efficiency have yet been received.

The station again coöperated with the Hawaiian Poultry Association in preparing an exhibit of agricultural and horticultural products. The winter season, which is best for a show of poultry, is quite unfavorable for a horticultural exhibition. Nevertheless, a considerable number of interesting things were brought in by the exhibitors.

Some interest has been manifested in the growing ot red peppers and an effort has been made to ascertain the probable market for these in the dried form. The wholesale price of these in New York ranges from 7½ to 15 cents per pound. The exact consumption has not yet been ascertained, but it is stated by one company that its annual purchases of cayenne pods amount to several hundreds of tons.

The Waialee Industrial School has grown Tabasco peppers on a small scale. The principal, Mr. T. H. Gibson, estimates that the cost of picking would be about 1 cent per pound. It is too early yet to have any accurate data as to the yields, but it would appear that this is a promising crop. It is certainly a crop that can be marketed at long distances. Several large dealers have requested that a sample of sufficient size for testing be shipped to them.

REPORT OF THE ASSISTANT CHEMIST.

By Alice R. Thompson.

CHEMICAL STUDIES OF RICE AND RICE PRODUCTS.

The principal work of the last year has been that of determining the composition of paddy, straw, and rice grain. Mr. F. G. Krauss, of this station, obtained the samples from rice grown under his direction and from rice imported from Japan for comparison. The question of the food value of rice grown in Japan is rather an important one, the Japanese claiming their rice to be of superior quality as regards richness, hence the preference shown by Japanese to the imported rice.

The samples analyzed were of three kinds of rice—one, the imported Japan rice, another the Hawaiian grown rice of the Japan variety, and the third, Hawaiian Gold Seed rice grown in Hawaii.

Each kind of rice was divided into two samples, one of rice thoroughly polished; the other, of rice still "in the brown."

The analyses of the rices are as follows:

Composition of different kinds of rice.

[Air-dry material.]

Variety	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Polished.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Imported Japan	13.72	6.39	0.64	76.76	1.81	0.68
Station-grown Japan	13.05	6.47	.71	76.66	2.24	.87
Hawaiian (Gold Seed)	14.10	6.78	.46	76.86	1.32	.48
In Brown						
Imported Japan	13.40	7.09	2.08	73.87	2.22	1.34
Station-grown Japan	13.02	6.79	2.10	74.09	2.35	1.65
Hawaiian (Gold Seed)	13.79	7.14	2.13	72.87	2.74	1.33

Composition of different kinds of rice.

[Dry-matter basis.]

Variety.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Polished.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Imported Japan	7.40	0.74	88.97	2.10	0.79
Station-grown Japan	7.44	.82	88.16	2.58	1.00
Hawaiian (Gold Seed)	7.89	.54	89.47	1.54	.56
In Brown.					
Imported Japan	8.18	2.40	85.31	2.56	1.55
Station-grown Japan	7.81	2.41	85.18	2.70	1.90
Hawaiian (Gold Seed)	8.28	2.47	84.53	3.18	1.54

As may be noticed, there is no very great difference in the chemical composition of the rices. Especially is this true where the polished rices are compared separately with the unpolished. It was to be expected, since the bran of rice is high in fat and protein, that the unpolished rice should have a higher fat and protein content than the polished. Comparing the rices, it is noticeable that the unpolished rice has from three to four times as much fat as the polished, and the protein content is from 0.8 to 0.4 per cent higher in the unpolished. The ash and fiber are also higher in the unpolished.

But as far as the varieties are concerned there is but little increase of food value in the Japan imported rice as compared with the Hawaiian grown rice, Japan or Hawaiian standard seed. In the polished condition there is about 0.4 per cent more fat in the Japan variety, but about 0.5 per cent more protein in the Hawaiian variety (comparing the results as set forth in the "water-free material" table). In the unpolished condition the protein and fat contents of the three samples are almost identical.

The nitrogenous constituents of the rices are shown in the following table:

Nitrogenous constituents of rice.

[Fresh material.]

Variety.	Total Nitrogen.	Proteid nitrogen.	Amid nitrogen.	Crude protein (total N x 6.25)	True protein (proteid N x 6.25)	Amids calculated as asparagin.
Polished.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Imported Japan	1.022	1.022	....	6.39	6.39	....
Station-grown Japan	1.035	1.035	....	6.47	6.47	....
Hawaiian (Gold Seed)	1.085	1.085	....	6.78	6.78	....
In Brown.						
Imported Japan	1.134	1.126	0.008	7.09	7.04	0.04
Station-grown Japan	1.087	1.081	.006	6.79	6.76	.03
Hawaiian (Gold Seed)	1.142	1.142	....	7.14	7.14	....

It will be seen that there is little or no difference between the total nitrogen and albuminoid nitrogen.

During the ensuing year, analyses will be made of other rices, but the work already indicates that the claim for the superiority of Japan imported rice over Hawaiian-grown rice will not hold so far as the nutritive value of the rices is concerned.

Analysis of rice paddy and straw of rices grown from seed of different varieties was made, also of rice of the same variety grown under different conditions. Samples were taken and dried by Mr. F. G. Krauss and sent to this laboratory for analysis.

The Japan Seed rice paddy has the lowest protein value. The Japan Seed rice and the dry-land grown rice contain a little more fat than the Gold Seed, and about 4 per cent more fiber. Studying the ash constituents, the Japanese rice and the dry-land grown rice contain the highest percentage of potash,—the Japan the least phosphoric acid,—the Hawaiian rice the most lime. The magnesia is about the same all through.

In one case the dry-land rice variety was grown under wet-land conditions. Under these conditions the protein and fiber became less, the lime a little higher, but no other especial change was produced.

The composition of the rice straw is not so definite as that of the paddy. Rice of the same variety varies. From the following tables, however, it is seen that the dry-land rice grown under dry-land conditions has less fiber but higher protein content than the other rice.

Composition of rice hay (straw and paddy).

[Air-dry material].

Variety of rice.	Proximate constituents.						Ash constituents.				
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Soda.	Lime.	Phosphoric acid.	Magnesia.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Japan Seed, grown at Kailua	9.85	4.04	1.67	46.02	24.30	14.12	1.567	0.288	0.547	0.323	0.219
Japan Seed, grown at station trial grounds	9.11	4.03	1.69	45.40	23.80	15.97	1.381	.273	.296	.364	.202
No. 65 (dry-land grown)	10.26	6.38	1.96	42.40	23.30	15.70	1.370	1.40	.264	.693	....
No. 68 (dry-land grown)	10.28	6.29	1.60	49.28	18.84	13.71	1.082	1.20	.214	.726	....
Standard Hawaiian Gold Seed, grown at trial grounds	9.72	4.21	1.47	43.48	24.81	16.31	1.850	.276	.350	.320	.259
Standard Hawaiian, grown at Palama	9.86	3.45	1.66	43.00	27.74	14.29	1.614	.641	.349	.280	.160
No. 65 grown under wet-land conditions	9.64	3.76	1.65	47.08	25.31	12.56	1.228	.330	.386	.381	.188

Composition of rice hay.

[Dry-matter basis.]

Variety of rice.	Proximate constituents.					Ash constituents.				
	Protein.	Fat	Nitrogen-free extract,	Crude fiber.	Ash.	Potash.	Soda.	Lime.	Phosphoric acid.	Magnesia.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Japan Seed, grown at Kailua	4.48	1.85	51.06	26.95	15.66	1.738	0.319	0.607	0.358	.0243
Japan Seed, grown at station trial grounds	4.43	1.86	51.96	26.18	15.57	1.519	.300	.326	.400	.222
No. 65 (dry-land grown)	7.09	2.18	47.28	25.96	17.49	1.526	1.560	.294	.772	....
No. 68 (dry-land grown)	6.97	1.78	54.99	20.99	15.27	1.205	1.337	.238	.809	....
Standard Hawaiian Gold Seed, grown at trial grounds	4.66	1.63	48.19	27.46	18.06	2.048	.306	.387	.354	.287
Standard Hawaiian, grown at Palama	3.83	1.84	47.72	30.76	15.85	1.790	.711	.387	.311	.177
No. 65 grown under wet-land conditions	4.16	1.82	52.14	27.99	13.89	1.358	.365	.427	.421	.208

Nitrogenous constituents of rice.

[Air-dry material.]

	Total nitrogen.	Proteid nitrogen.	Amid nitrogen.	Crude protein (total N x 6.25).	True protein (proteid N x 6.25).	Amids calculated as asparagin.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Paddy.						
Japan Seed (Kailua)	0.938	0 936	0.002	5.86	5.85	0.01
Japan Seed (trial grounds)	.990	.962	.028	6.19	6.01	.13
Dry-land No. 65	1.667	1.462	.205	10.42	9.14	.96
Dry-land No. 68	1.247	1.247	.000	7.79	7.79	.00
Standard Hawaiian (trial grounds)	1.382	1.381	.001	8.64	8.63	.01
Standard Hawaiian (Palama)	1.117	1.117	.00	6.98	6.98	.00
Dry-land No. 65 grown under wet-land conditions	1.094	1.094	.00	6.84	6.84	.00
Straw.						
Japan Seed (Kailua)	.400	....	....	2.50	....	....
Japan Seed (trial grounds)	.472	.403	.059	2.950	2.520	.32
Dry-land No. 65	.696	.585	.111	4.35	3.66	.52
Dry-land No. 68	.768	.744	.024	4.80	4.65	.11
Standard Hawaiian (trial grounds)	.438	.391	.047	2.74	2.44	.22
Standard Hawaiian (Palama)	.327	.289	.038	2.04	1.81	.18
Dry-land grown under wet-land conditions	.405	.364	.041	2.53	2.28	.19
Hay.						
Japan Seed (Kailua)	.646	....	....	4.04	....	....
Japan Seed (trial grounds)	.644	.589	.055	4.03	3.68	.26
Dry-land No. 65	1.019	.877	.142	6.37	5.48	.67
Dry-land No, 68	1.007	.995	.012	6.29	6.22	.06
Standard Hawaiian (trial grounds)	.674	.638	.036	4.21	3.99	.17
Standard Hawaiian (Palama)	.552	.525	.027	3.45	3.28	.13
No. 65 grown under wet-land conditions	.602	.572	.030	3.76	3.58	.14

Composition of paddy.

[Air-dry material.]

Variety of rice.	Proximate constituents.						Ash constituents.				
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Soda.	Lime.	Phosphoric acid.	Magnesia.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Japan Seed, grown at Kailua	12.01	5.86	1.97	63.32	10.86	5.98	0.511	0.069	0.080	0.577	0.206
Japan Seed, grown at station trial grounds	11 47	6.19	1.95	64.46	10.25	5.68	.503	.119	.090	.660	.235
No. 65 dry-land grown	11.54	10.42	2.19	59.36	10.84	5.65	.470	.114	.113	.740	....
No. 68, dry-land grown....................	11.30	7.79	1.77	61.52	10.30	7.32	.438	.125	.106	.785	....
Standard Hawaiian Gold Seed, grown at station trial grounds	11.58	8.64	1.47	64.46	7.46	6.39	.370	.023	.140	.692	.211
Standard Hawaiian Gold Seed, grown at Palama..	11.78	6.98	1.64	66.30	7.66	5.64	.346	.095	.170	.698	.235
No. 65 grown under wet-land conditions, at Palama	11.93	6.84	1.86	65.47	8.20	5.70	.449	.069	.170	.730	.246

Composition of paddy.

[Dry-matter basis.]

Variety of rice.	Proximate constituents.					Ash constituents.				
	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Soda.	Lime.	Phosphoric acid.	Magnesia.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Japan Seed, grown at Kailua	6.66	2.24	71.97	12.34	6.79	0.583	.078	.091	0.655	0.234
Japan Seed, grown at station trial grounds.....	6.99	2.20	72.83	11.57	6.41	.568	0.134	.102	.745	0.265
No. 65, dry-land grown ...	11.78	2.47	67.12	12.25	6.38	.531	0.129	.128	.836	....
No. 68, dry-land grown ...	8.78	1.99	69.37	11.61	8.25	.494	0.141	.119	.885	....
Standard Hawaiian Gold Seed, grown at station trial grounds.....	9.77	1.66	72.90	8.44	7.23	.418	.26	.158	.783	.239
Standard Hawaiian Gold Seed, grown at Palama	7.89	1.85	75.23	8.66	6.37	.391	.107	.192	.789	.266
No. 65, grown under wet-land conditions at Palama	7.76	2.11	74.35	9.31	6.47	.510	.078	.193	.829	.279

Composition of rice straw.

[Air-dry material]

Variety of rice.	Proximate constituents.						Ash constituents.				
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Soda.	Lime.	Phosphoric acid.	Magnesia.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Japan Seed, grown at Kailua	8.77	2.50	1.52	37.99	31.02	18.20	2.096	0.398	0.625	0.197	0.181
Japan Seed, grown at station trial grounds	8.25	2.95	1.57	35.51	30.59	21.13	1.821	.350	.400	.216	.185
No. 65, dry-land grown	9.62	4.36	1.84	33.92	29.53	20.73	1.820	.154	.340	.670	....
No. 68, dry-land grown	9.26	4.80	1.44	37.01	27.39	20.10	1.727	.115	.323	.667	....
Standard Hawaiian Gold Seed, grown at station trial grounds, (wet-land)	9.10	2.74	1.48	36.48	30.59	19.61	2.350	.361	.420	.197	.275
Standard Hawaiian Gold Seed, grown at Palama (wet-land)	9.09	2.04	1.67	33.68	35.77	17.75	2.121	.860	.420	.114	.130
No. 65, grown under wet-land conditions at Palama	8.72	2.53	1.56	37.44	32.16	17.59	1.540	.435	.473	.242	.166

Composition of rice straw.

[Dry-matter basis.]

Variety of rice.	Proximate constituents.					Ash constituents.				
	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Soda.	Lime.	Phosphoric acid.	Magnesia.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Japan Seed, grown at Kailua	2.74	1.67	41.64	34.00	19.95	2.297	0.436	0.685	0.216	0.198
Japan Seed, grown at station trial grounds	3.21	1.71	38.76	33.31	23.01	1.983	.381	.463	.235	.201
No. 65, dry-land grown	4.81	2.04	37.56	32.66	22.93	2.013	.170	.376	.741	....
No. 68, dry-land grown	5.29	1.59	40.79	30.18	22.15	1.903	.127	.356	.735	....
Standard Hawaiian Gold Seed, grown at station trial grounds, (wet-land)	3.01	1.63	40.14	33.65	21.57	2.585	.397	.462	.217	.303
Standard Hawaiian Gold Seed, grown at Palama (wet-land)	2.31	1.84	37.03	39.31	19.51	2.331	.945	.461	.125	.143
No. 65, grown under wet-land conditions at Palama	2.77	1.71	41.04	35.22	19.26	1.686	.476	.518	.265	.182

As for its ash constituents, the dry-land variety of straw takes up less lime but much more phosphoric acid than the other rices.

In case the dry-land variety is grown under wet-land conditions, the crude fiber and lime increase and the protein and phosphoric acid decrease. There is not much difference between the Japan wet-land rice and the Hawaiian wet-land rice.

The composition of rice hay is calculated from the analyses of both paddy and straw, knowing the proportion of paddy to straw. Only the dry-land rice hay is at present of practical importance as it can be most cheaply grown. As it has the highest protein content, it will be of more value as a fodder.

MISCELLANEOUS FODDERS.

Besides the analyses of several samples of rice hay as fodder, two samples of Rhodes grass, one of cassava waste, three of leguminous plants, and one of American wheat hay were analyzed.

The Rhodes grass, compared with the wheat hay, contains a higher percentage of protein, about the same amount of fat, fiber and ash, and about twice as much lime.

The legumes (tops analyzed) have an especially high protein content, the pigeon pea containing the most nitrogen. The fat content of the cowpea is lower than that of American cowpeas, but the jack bean and pigeon pea contain a good deal of fat (as estimated by ether extraction). The cowpea has a higher fiber content than the average pea grown in America.

The legumes were grown on the station grounds and the yields per acre, estimated by Mr. F. G. Krauss, are as follows: Cowpea, 17,000 to 22,000 pounds; pigeon pea, 8,100 to 11,000 pounds; jack bean, 11,000 to 15,000 pounds.

The analyses of the fodders are given in the following tables:

Composition of miscellaneous fodders.

	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
Air-dried.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Rhodes grass hay	11.75	6.08	2.31	42.51	30.20	7.15	1.314	0.730	0.280
Rhodes grass hay	9.87	7.25	1.39	44 64	29.21	7.64	....	.805	....
Wheat hay	9.44	4.48	1.82	45.14	31.80	7.32	....	.375	....
Fresh material.									
Cow-pea (*Vigna catjang*)	83.15	3.71	.22	5.26	5.75	1.91	.681	.290	.183
Pigeon-pea (*Cajanus indicus*)	70.00	7.11	1.65	7.88	10.72	2.64	.904	.428	.259
Jack bean (*Canavalia ensiformis*	76.81	5.21	.48	8.44	6.36	2.70	.650	.780	.162

Composition of miscellaneous fodders.

[Dry-matter basis.]

	Proximate constituents.				Ash constituents.		
	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Potash.	Lime.	Phosphoric acid.
Rhodes grass ;	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Sample No. 1	6.88	2.62	48.19	34.21	1.49	0.83	0.32
Sample No. 2	8.07	1.54	49.53	32.39	....	.892	....
Cassava	1.36	.58	87.36	9.06	.32	.470	.117
Cow-pea (*Vigna catjang*)	21.99	1.33	31.20	34.15	4.04	1.72	1.087
Pigeon pea, (*Cajanus indicus*)	23.69	5.51	26.26	35.73	3.014	1.425	.862
Jack bean (*Canavalia ensiformis*)	22.44	2.08	36.42	27.42	2.801	3.365	.697
Wheat hay	4.95	2.01	49.84	35.12	....	.414	....

Nitrogenous constituents of miscellaneous fodders.

(Fresh material).

	Total Nitrogen.	Proteid Nitrogen.	Amid Nitrogen.	Crude protein (total N x 6.25).	True protein (proteid N x 6.25).	Amids calculated as asparagin.
Rhodes grass:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sample No. 1	.972	0.760	0.212	6.08	4.75	1.00
Sample No. 2	1.160	.956	.204	7.25	5.98	.96
Cassava	.190	.190	.....	1.19	1.19	......
Cowpea (*Vigna catjang*).	.593	.424	.169	3.71	2.65	.80
Pigeon pea (*Cajanus indicus.*).	1.137	.998	.139	7.11	6.24	.65
Jack bean (*Canavalia ensiformis*).	.833	.629	.204	5.21	3.93	.96
Wheat hay	.717	.611	.106	4.48	3.82	.50

FERTILIZER ANALYSES.

But five samples of materials intended for fertilizers have been analyzed as follows:

Analyses of Fertilizer Materials.

Fertilizer Materials.	Moisture.	Phosphoric Acid.	Potash.	Nitrogen.	Lime.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Castor pomace	10.72	1.818	1.310	5.190	1.02
Peanut meal	10.59	1.642	1.284	8.360	.46
Cowpea (*Vigna catjang*)	83.15	.101	.408	.526	.491
Pigeon pea (*Cajanus indicus*)	70.00	.202	.788	.783	.312
Jack bean (*Canavalia ensiformis*)	76.81	.218	.783	.723	.438

The castor pomace and peanut meal were imported from China. It is believed that neither the pomace nor the meal will ever come into general use in these islands, as commercial fertilizers are extensively used and apprecited; and the more inferior organic fertilizers cannot take their place.

The legumes (whole plant analyzed) have a high nitrogen content. The analyses of the cowpea grown at this station show a higher content of nitrogen, phosphoric acid, and potash than that found in cowpeas grown in America. The jack bean compares favorably with the cowpea in composition. The pigeon pea (a tropical plant) and the jack bean contain the most nitrogen. These legumes may be especially appropriate as fertilizers for Oahu coast soils, where the humus is deficient.

The yields per acre of legumes (roots included) raised at this station were as follows: Cowpea, 18,000 to 23,000 pounds; pigeon pea, 9,000 to 12,000 pounds, and jack bean, 15,000 to 19,000 pounds.

SOILS.

A number of samples of soils were analyzed during the year, as follows:

Analysis of samples of Hawaiian soils.

No. of sample	Moisture.	Organic matter and combined water.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.	Manganese oxide.
	Per Cent	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
1	14.141	....	0.505	0.185	0.178	0.59	1.622	0.115
2	15.263	....	.555	.277	.151	.69	2.204	.130
3	3.763	15.864	.295	.127	.547	.940	.450	.400
4	9.429	10.441	.193	.223	1.553	3.29	....	.120
5	....	....	.148	....	.254	.57	....	....
6	8.907	14.726	.328	.198	.248	2.280	1.672	.120
7	7.536	13.660	.226	.127	.148	1.720	1.564	.130

The two soils, Nos. 1 and 2, are pineapple soils obtained from a field near Hilo, Hawaii. No. 1 is a brown loam, acid in reaction, taken from the Hamakua end of the field; No. 2 is also a brown loam, acid to litmus, and taken from the Puna end. The lime content is low in both soils, which fact accounts for the acidity noticed. The potash is low also.

Soil No. 3 came from upper Hoaeae and is a dark red loam, neutral in reaction with litmus. It contains a great abundance of humus; the nitrogen and potash are high; the lime rather low for the kind of soil, and the phosphoric acid low for a Hawaiian soil. Pineapples are growing well on the land.

No. 4 comes from land near Diamond Head and is a brown clay loam, effervescing with acid, showing presence of calcium carbonate. The humus is very low, scarcely coloring the potash solution. Results indicate that the lime is high, the phosphoric acid and nitrogen fair, and the potash abnormally high (sample may be an abnormal one). A crop of legumes grown and turned under on the land would probably improve the land, as there is very little humus.

Another soil from land near Diamond Head was also examined and proved to contain no humus at all. A large amount of effervescence followed action of acid on the soil, showing presence of much calcium carbonate. This soil contained but 0.098 per cent nitrogen.

Soil No. 5 came from the Palama district of this island, and is a red clay loam, neutral to litmus. The soil is rather low in potash and lime.

One soil was obtained from Palolo Valley and lime advised for it, as it was found to be quite acid.

The nitrogen was determined in five rice soils of Oahu and is as follows: Kailua, 0.186 per cent; Palama, 0.328 per cent; Punaluu soils toward litmus was acid, that of the station trial trial grounds, 0.224 per cent. The reaction of the Kailua and Punaluu soils toward litmus was acid, that of the station trial grounds slightly acid, and that of the Palama and Waikiki soils neutral.

Soils Nos. 6 and 7 are rice soils, obtained from Palama and Punaluu, respectively. No. 6 is a brown clay loam, and the analysis indicates a small deficiency of potash, while the lime is high. No. 7 is a dark brown loam and is deficient in potash and phosphoric acid, but high in lime. In both soils the lime content is higher than the magnesia, which relation is often found reversed in Hawaiian soils.

WATER ANALYSES.

One sample of irrigation water from Hilo was analyzed and found to contain 78.27 grains of total solids, and 35.23 grains of salt per gallon. This explained the dying of young fruit trees irrigated with this water.

Fourteen samples of drainage water from a rice lysimeter experiment were analyzed for potash, phosphoric acid, magnesia, lime, and nitrogen. The results indicate that ammonium sulphate used as a fertilizer causes loss of lime in the soil. Addition of magnesium salts causes an increase of magnesia in the drainage water. Only traces of phosphoric acid were found in the sample of water.

MISCELLANEOUS WORK.

The wax left in slum gum from which wax had been extracted by a new method was determined. Only 25.27 per cent wax was found. The percentage of slum gum left on extraction was also very small.

A sample of koa bark sent from Hawaii contained 19.91 per cent tannin in the water-free material. A sample of ohia bark had but 5.73 per cent tannin in the water-free state. No further effort has been made by those interested in koa bark to obtain tannin.

A fertilizer experiment was carried out with rubber plants, using paraffin pots and fertilizers, according to the wire-basket method devised by the Bureau of Soils of the U. S. Department of Agriculture.[a]

The soil used was from station land. The idea was to study the effects of different fertilizers on the rubber plant of the Para variety in soil of station land type. The results are as follows:

(*Pot Experiments with fertilizers for Para rubber.*)

Fertilizer used.	Average transpiration.	Average weight of plant.
	Grams.	*Grams.*
Check	10.95	3.14
Phosphoric acid	11.56	3.42
Sulphate of potash	11.42	3.55
Nitrate of soda	16.58	3.90
Lime	13.05	3.22
Manure	15.50	3.56
Phosphoric acid and sulphate of potash	17.16	3.83
Phosphoric acid and nitrate of soda	10.50	3.40
Nitrate of soda and sulphate of potash	13.20	3.29
Phosphoric acid, lime, nitrate of soda, and sulphate of potash	7.06	2.45
Phosphoric acid, nitrate of soda, and sulphate of potash	12.35	3.18

Where manure, sodium nitrate, or lime was the single fertilizer the transpiration increased materially. Acid phosphate or potassium sulphate alone gave but a slight increase. The combinations of acid phosphate and potassium sulphate gave a large increase, but acid phosphate in the other combinations either decreased the transpiration or gave but little increase.

An experiment with Ceara rubber was carried out. The best results were obtained with lime, sodium nitrate, and the two combinations, sodium nitrate and potassium sulphate, and sodium nitrate, potassium sulphate, and acid phosphate. Manure alone and potassium sulphate alone gave fair results. Acid phosphate, except in the one combination already cited, gave poor results. These pot experiments indicate that sodium nitrate used alone makes a good fertilizer for rubber trees, while acid phosphate has some deleterious effect upon them.

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[a] U S. Dept. Agr., Bur. Soils Circ. 18.

FIELD CROP EXPERIMENTS.

By F. G. Krauss.

The following subjects are treated in this report: Rice investigations, including tests of old and new varieties; fertilizer experiments, upland rice as a hay and grain crop, and salt marsh rice hay experiments; Chinese and Japanese mat rush experiments; cotton experiments; soy beans; peanuts; and Leghorn wheat.

RICE INVESTIGATIONS—REPORT OF SECOND YEAR'S EXPERIMENTS.

INTRODUCTION.

The rice experiments covering the past year are a continuation of the investigation begun two years ago. The work has thus far followed closely the original outline as set forth in A Preliminary Report on Rice Investigations. (See Pl. IV). In the search for rotation and substitute crops for our rice lands, a number of new crops are being tested. Among these may be mentioned the Chinese and Japanese mat sedges for the lowlands; cotton for the dry uplands; soy beans and peanuts for intermediate conditions.

A brief sketch of the rice industry in Hawaii appeared in the first report of these investigations.

Industrial and commercial statistics of the industry, compiled from original sources, are given herewith for reference.

THE MILLING INDUSTRY.

The milling of rice is not confined to the Chinese, as is the cultural phase of the industry. One of the largest and most modern of the rice mills is conducted by Mr. H. E. Walker in Honolulu. Another large modern mill is that of the City Mill Company, of which Mr. Chung K. Ai is manager. The Japanese Rice Mill Company is another large Honolulu concern which mills imported Japan rice exclusively.

The maximum capacity of the largest mills is about 100,000 bags of clean rice per annum. As two crops are harvested during the year, besides the large importations of Japan rice in the "brown," the larger mills are run during a large part of the year. The majority of the fifty odd mills in the islands are of antiquated Chinese pattern, the product of which does not equal the highly finished American article, which is not sought by the oriental trade of Hawaii.

Below is given a list of the principal Hawaiian rice mills having a capacity of 10,000 or more bags clean rice per annum. Honolulu is the principal milling center.

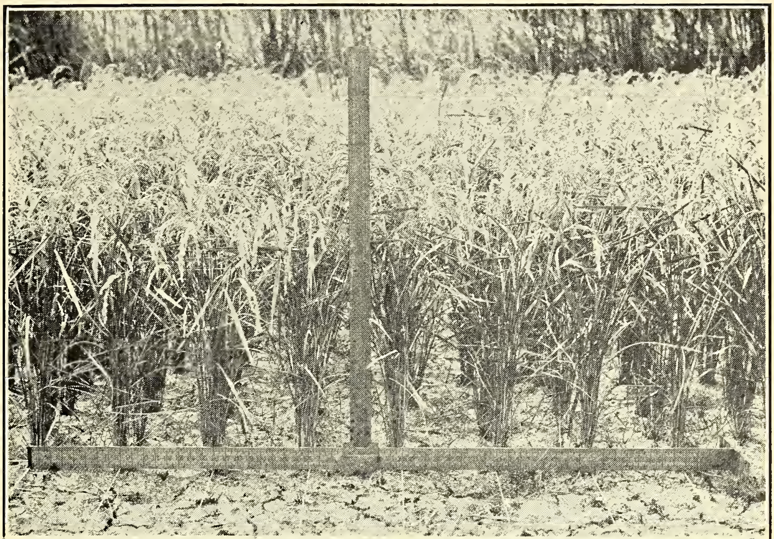
Principal rice mills of Hawaii.

Name of mill.	Location.	Type of Mill.	Approximate capacity (clean rice)	Kind of Rice milled.	
				Hawn.	Japanese
			Bags.	*Bags.*	*Bags.*
	OAHU.				
City Mill Co	Honolulu	Modern	45,000	15,000	30,000
C. Ah Loong Mill	do	Antiquated	10,000	7,000	....
Iwilei Rice Mill...........	do	do	10,000	10,000	....
Japanese Rill Mill Co.	do	Modern	100,000	....	100,000
Kaalaea (Sing Chong Co)	Heeia	Antiquated	13,000	13,000	....
Kaneohe Rice Mill Co. Ltd.........	Kaneohe	Modern	16,000	16,000	....
Kimura S. Rice Mill ...	Honolulu	do	20,000	....	20,000
Waialua Rice Mill (Sing Chong Co)	Pearl City	Antiquated	26,000	26,000	....
Walker's Rice Mill......	Honolulu	Modern	68,000	3,000	65,000
Wing Chong Can Co...	do	Antiquated	14,000	14,000	....
Wong Kwai Mill	Punaluu	do	12,000	12,000	....
Wong Leong Rice Mill	Waimanalo	do	11,000	8,000	3,000
	KAUAI.				
Hee Fat	Hanalei	....	4,200	....	....
Hee Fat	Kapaa	....	11,250	....	....
Man Sing Co......	Hanalei	....	11,000	....	....
Pah On Mill..	Waimea	....	16,000	....	....

The total yield of rice on the Island of Hawaii does not exceed 11,000 bags clean rice per annum. The Palolo Rice Mill Kohala, mills about 3,000 bags; Waipio Rice Mill at Kukuihaele, mills about 6,000 bags; Halawa Rice Mills, about 2,000 bags. The island of Maui grows and mills less than 5,000 bags and Molokai only about 500 bags per annum.

Comparatively little of the 50,000,000 pounds of rice grown in Hawaii is exported from the islands. The imports of Japan rice are large. The amount of rice imported from the United States is about equal to that exported from Hawaii.

PLATE IV. Fig. 1. Uniform planting in rice experiments.



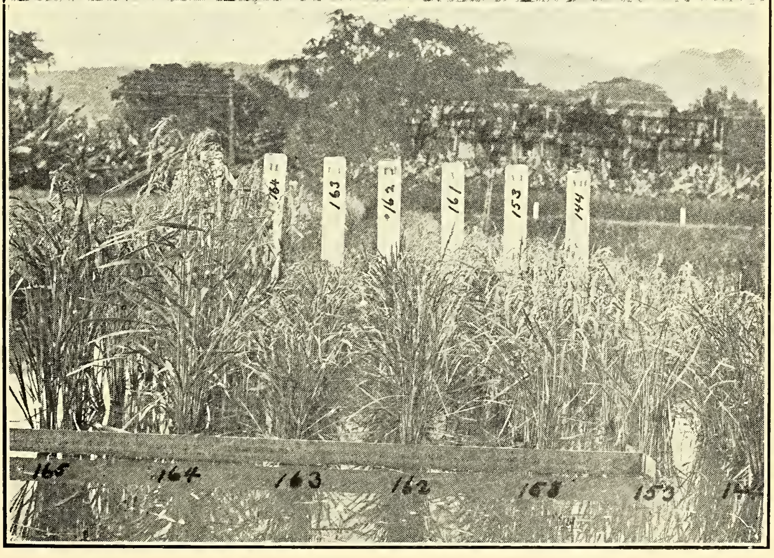


Fig. 2. Seven types of Japan rice

Below are given the U. S. customs statistics covering the imports and exports of rice to and from Hawaii for the five years ending June 30, 1907.

Imports of rice into Hawaii.

Year.	Japan.		China.		United States.	
	Amount.	Value.	Amount.	Value.	Amount	Value.
	Pounds.	*Dollars.*	*Pounds.*	*Dollars.*	*Pounds.*	*Dollars.*
1903	10,194,030	234,273	58,125	926	2,209,920	102,008
1904	19,044,460	443,920	341,113	4,449	3,642,925	143,142
1905	9,656,796	221,116	11,964	245	9,983,491	303,029
1906	12,496,396	283,653	22,600	529	4,129,643	164,683
1907	21,012,842	539,021	13,906	351	755,050	34,144

The exports to the United States from Hawaii during the same period were:

Exports of rice to the United States from Hawaii.

Year.	Amount.	Value.
	Pounds.	*Dollars.*
1903	234,930	$10,218.00
1904	31,911	1,610.00
1905	2,771,083	84,414.00
1906	5,739,500	223,012.00
1907	3,324,107	147,439.00

Acknowledgement is made of the valuable assistance and coöperation of rice planters, station workers, and others who have aided in the past year's experiments. The station's thanks are also due the Hawaiian Fertilizer Company and The Pacific Guano and Fertilizer Company, of Honolulu, for their liberal donation of fertilizers used in the past two year's experiments.

TEST OF OLD AND NEW VARIETIES OF RICE.

During the past year a third comparative test was made of some 130 varieties of rices originally obtained from the U. S. Department of Agriculture through the Office of Experiment Stations. This experiment completes two fall and one spring test of a representative list of varieties. Another spring test is planned for 1909 and the data of the four tests will be compiled in the form of a classified descriptive list.

The past season was favorable to growth and the same general cultural methods were adopted as in former tests. As in the two preceding tests, all the stocks were selected from individual mother plants; two such selections were sown of each variety, the object being to double the range of selection. On the whole, this test again demonstrates the good results to be obtained from careful selection.

As in the previous tests, all the varieties came true to type, thus confirming our original observations that natural hybridization does not readily take place in the field.

While a number of varieties might be eliminated at this time, it seems best that a fourth and final test be made before discarding any of the varieties now under test.

During the year, pure strains of the most promising varieties of last year were grown in quantity and disseminated among the rice growers generally. Of these, variety No. 19 (S. P. I. Inv. No. 12508), said to have been experimentally grown at the Georgetown Botanical Gardens from imported Ceylon stock, has thus far proved the most noteworthy. This variety proved very uniform in type from the start. The mother plant, selected from among the first progeny, produced 26 fruiting culms, which yielded 59 grams paddy, numbering 1,176 seeds. Two hundred plants in the test row produced over 17 pounds of paddy; and 10 pounds of stock seed transplanted to one-third acre, yielded 1,680 pounds choice paddy, on unfertilized land. This represents an increase of 168 fold and an acre yield of 5,040 pounds paddy under field conditions.

The culinary qualities of rice No. 19 are excellent. The milled grain is long, slender, hard and translucent, a type highly prized by the Chinese upper class. Considering the type, the milling qualities are fair, the paddy yielding about 62 per cent of prime rice. This rather large loss in milling is principally due to the unusually long slender grains which fracture in the process of hulling.

Variety No. 19 is suitable for fall culture only. July and August plantings mature in from 120 to 140 days. When planted in the spring it continues to vegetate till late in the fall and matures with late planted crops. As this variety tillers extraordinarily, 80 fruiting culms having been obtained from a single seed, with 25 as an average, not more than two or three seedlings should be set in a clump at transplanting.

A carefully developed strain of Japan rice, No. 153, now in its fourth generation of selection, is meeting with much favor among the several growers who have tried it. It matures in 110 days from planting, and yields equally with the more slowly maturing Hawaiian type of Gold Seed. The Japanese, who are the principal consumers of the Japan Seed rice, appear to regard the locally grown product with less prejudice, as its quality becomes better known.

In this connection, the chemical composition of the Japan and Hawaiian grown stocks is of interest. It was claimed by the Japanese that the local product lacked in "strength," "richness," and "fattiness," as well as flavor. The following analyses were made by the Bureau of Chemistry, U. S. Department of Agriculture, and confirm the analyses made by this station:

Chemical analyses of imported and Hawaiian grown Japan rices.

	Moisture.	Protein (N x 6.25)	Fat.	Carbohydrates by difference.	Crude fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Imported Japan (in brown)...	10.97	7.19	2.08	77.53	1.02	1.21
Hawaiian grown Japan (in brown).....................	10.40	7.38	2.23	77.26	1.07	1.66
Imported Japan (fully milled)	11.16	6.63	.38	80.91	.46	.49
Hawaiian grown Japan (fully milled)..................	10.76	7.31	.58	79.93	.60	.82

A comparison of the above data shows that instead of being inferior to the imported product, the Hawaiian grown Japan rice contains a higher percentage of fat and nitrogenous matter, the properties that would seem to determine the so-called "richness," "fattiness," and "strength."

A selection from variety No. 39 (S. P. I. Inv. No. 12582), a Georgia strain of Gold Seed, continues to gain headway against the Hawaiian type of this standard form of rice.

Variety No. 65 (S. P. I. Inv. No. 17144), the Egyptian variety similar to the Japan type, maintains its excellent yielding qualities, but is not liked by the Japanese consumers, who claim that it lacks in flavor. Besides, it is slower in maturing than the Japan sorts, which now produce satisfactory yields. However, this variety is especially well adapted for use as a hay crop, it is nutritious, the hulls of the seed are smooth, and the kernel is soft. It succeeds well with a minimum amount of irrigation. At a lower price than is asked for standard sorts, large quantities of the grain would be used in the manufacture of the Japanese food product, "Miso."

Variety No. 152, the Ay-Yujip rice, from the Igorrote country, Philippine Islands, which gave exceptional promise in the first comparative test, failed utterly in an extensive planting at Punaluu, along side of variety No. 19. While the general growth was satisfactorily, it failed to set seeds. Grown at the trial grounds near Honolulu, the results, while not equal to the first test, were fairly good. No explanation can be offered for this difference in behavior except that the excessive winds prevailing during the flowering season may have prevented pollination. No. 73, a Philippine rice called "Mokalit," of the Chinese "No-mai" type, also yielded well.

Five new Japan rices, three of which, Nos. 161, 162, and 163, were kindly sent to the station by Dr. Y. Otsuka, Chief of the Kiushu Agricultural Experiment Station, at Kumamoto, Japan; and Nos. 164 and 165, which were presented to the station by Mr. McQuaid, of the Kona Developing Company, Island of Hawaii, who secured them from Japanese farmer at south Kona, were tested in comparison with the two Japan varieties previously grown (Nos. 144 and 153). (See Plate V). All the varieties made a good growth and are considered promising. Of these, variety No. 164 has given splendid results both in submerged and upland culture, and a half acre is being grown in two widely separated localities this year. Variety No. 165 is also a heavy yielder, doing well under both dry and wet land culture, but its opaque kernel, which limits its use to the "Mochi-gomi" of the Japanese, and "No-mai," or cake flour, of the Chinese, will prevent its extensive planting, except possibly as a stock feed or for the manufacture of "Miso."

The following milling test was made by the City Mill Company at Honolulu:

	Prime Rice	Broken Rice.
	Per Cent.	*Per Cent.*
Rice No. 19	62	4.0
Rice No, 39	61	3.0
Rice No. 65	67	1.0
Rice No. 73	67	1.0

Better results would perhaps be obtained on large quantities of rice.

The upland rices, Nos. 65, 68, and 154a, yielded slightly less during the past year than the year previous, but a good quality of stock seed was secured. Nos. 67 and 154b have been discarded as inferior to the other varieties.

Pure strains of stock seed of Nos. 19, 39, 65, 68, 73, 153 and 154a, are now available for distribution. (See Pl. V).

FERTILIZER EXPERIMENTS.

EXPERIMENT I. RESIDUAL FERTILIZER EXPERIMENT.

The object of this experiment was to determine the residual value upon the spring crop of Japan and Gold Seed rice, of fertilizers that were applied to the previous fall crop. The experiment is a continuation of "fertilizers experiment III" (1907), which is reported in detail in the first report of rice investigations.[a]

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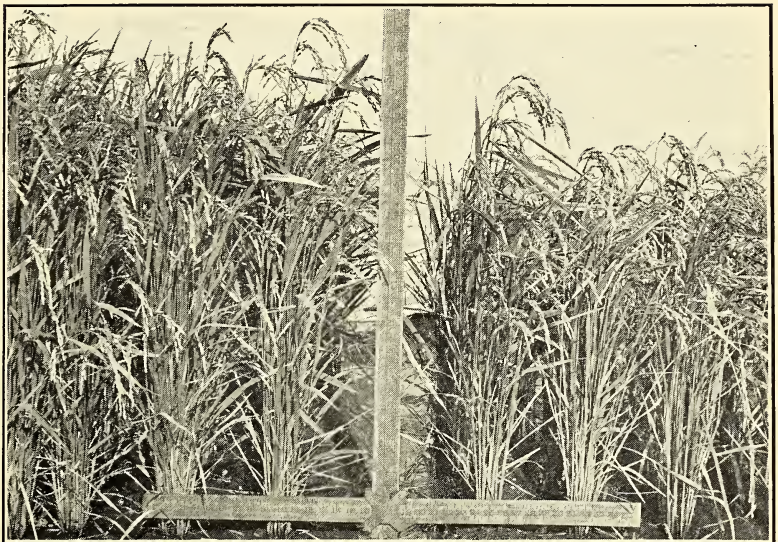
[a] Hawaii Sta. Rpt 1907, p. 81.

PLATE V. Fig. 1. Relative growth from equal amounts sulphate of ammonia (on left) nitate of soda (on right.)



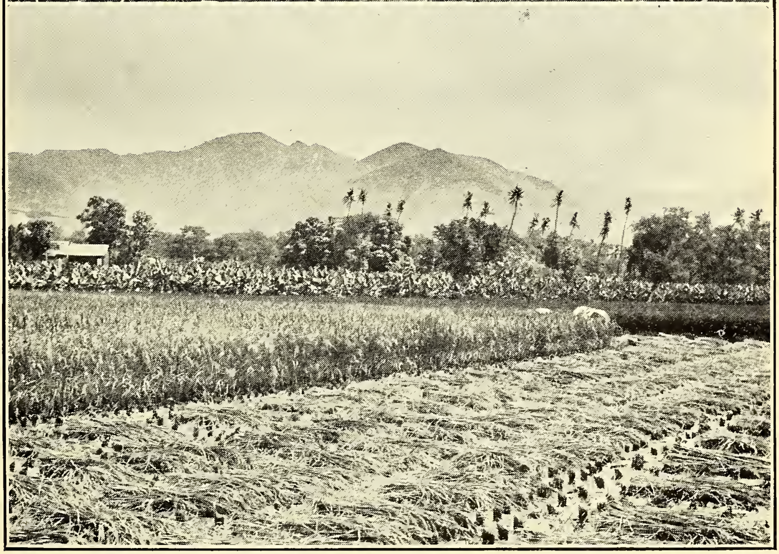


Fig. 2. Harvesting salt marsh rice for hay.

Owing to the depredations of rice birds upon the late maturing Gold Seed of the 1907 direct fertilization experiment, no comparative data are available for the corresponding variety in the residual experiment herein reported.

The following table gives the results of this experiment:

Relative residual value of the various commercial forms of fertilizers, on rice, paddy produced by 100 clumps of rice. (a)

Plat number.	Fertilizer applied.	Amount per acre.	Equivalent.	Check (untreated). Average of 10 plats.		Fertilized before planting.		Limed (750 lbs.) and fertilized before planting.		Fertilized after plants were three-fourths grown.	
				Japan Seed.	Gold Seed.	Japan Seed.	Gold Seed.	Japan Seed.	Gold Seed.	Japan Seed.	Gold Seed.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Nitrate of soda	266	40 N	2.3	2.6	2.4	(*b*)	2.7	4.4	2.5	(*b*)
2	Sulphate of ammonia	200	40 N			2.5	3.8	2.5	4.0	3.3	4.6
3	Sulphate of potash	95	45 K_2O			2.3	2.7	2.4	3.3	3.1	4.5
4	Sulphate of potash and magnesia	180	45 K_2O 61 $MgSO_4$			2.3	2.7	2.4	3.2	3.4	4.7
5	Acid phosphate	125	25 P_2O_5			2.4	2.6	2.6	3.4	3.1	5.1
6	Reverted phosphate	156	25 P_2O_5			2.2	3.2	3.5	3.7	3.1	4.5
7	Thomas slag phosphate	156	25 P_2O_5 62 CaO			2.4	3.0	2.5	3.6	3.0	4.3
8	Complete fertilizer A (nitrate of soda, acid phosphate, and sulphate of potash)	350	28 N 17.5 P_2O_5 31.5 K_2O			2.3	3.7	2.4	3.8	2.6	4.5
9	Complete fertilizer B (sulphate of ammonia, fish guano, reverted phosphate, and sulphate of potash)	350	28 N 17.5 P_2O_5 31.5 K_2O			2.2	3.7	2.3	4.0	2.5	4.2
10	Complete fertilizer C (nitrate of soda, Thomas slag phosphate, and sulphate of potash and magnesia	350	28 N 17.5 P_2O_5 31.5 K_2O			2.3	3.0	2.5	3.0	2.6	4.0

(*a*) Results from materials containing a single fertilizer constituent not comparable with the complete fertilizers which contain only 70 per cent of the constituents applied singly, although the preparations are the same.

(*b*) Weight lost.

SUMMARY.

From the data given in the preceeding (allowing 0.3 pound for experimental error), it would appear that the Japan Seed received no residual value from any of the fertilizing materials when applied to the previous crop before planting; but that the Gold Seed was benefited to the extent of 34 per cent increase from the residual effects of sulphate of ammonia, 11 per cent from the reverted phosphate, 0.3 per cent from the Thomas slag phosphate, 30 per cent each from complete fertilizers A and B, and 0.3 per cent from complete fertilizer C.

When limed with 750 pounds of slacked lime in addition to fertilizing before planting, the Japan Seed failed to show any increase in yield, due to any of the treatments. On the other hand, Gold Seed appears to show decidedly increased yields under like conditions. This may be due to the more vigorous and longer period of growth characteristic of the latter variety, and would indicate that liming may prove beneficial when applied to a neutral soil, provided it is applied sufficiently in advance of planting the crop.[a]

The largest residual value was received by both varieties of rice when the fertilizers were applied to the previous crop when three-fourths grown. Thus allowing 13 per cent for experimental error, we get the following results:

Residual value of fertilizer materials when applied to the previous crop three-fourths grown.

Treatment.	Increase over untreated plats.	
	Japan Seed Paddy.	Gold Seed Paddy.
	Per Cent.	*Per Cent.*
Nitrate of Soda	00	* (*a*)
Sulphate of Ammonia	30	63
Sulphate of Potash	21	60
Sulphate of Potash and Magnesia	34	67
Acid Phosphate	21	83
Reverted Phosphate	21	60
Thomas slag Phosphate	17	52
Complete Fertilizer A*b*	00	60
Complete Fertilizer B*b*	00	48
Complete Fertilizer C*b*	00	40

* *a* Weight lost.

b Contains only 70 per cent of the constituents applied singly and therefore not comparable.

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[a] The application of lime to the previous crops lowers the yield in every instance. See Experiment III, Hawaii Sta. Rpt. 1907, p. 81.

Experiment II. Residual Fertilizer Experiment (b).

This experiment is a continuation of pot fertilizer experiment II of the 1907 series.[a]

After lying fallow in the pots for six months, the originally fertilized soil was submerged under several inches of water, as is the custom in field culture. When thoroughly softened the mud was stirred to a depth of 4 inches and then left to settle.

Five 15-day-old seedlings of selected Japan Seed rice No. 153 were transplanted into each pot, three pots forming a series.

The plants grew well, and the paddy of all the series was harvested at one time, even though a few days difference in maturity was apparent in some of the series.

The residual value of the various commercial fertilizer materials as shown by pot cultures when the fertilizers were applied to the previous crop at the rate of fifty pounds per acre of each element, is shown below:

Residual effect of fertilizers in pot cultures with Japan rice.

Series.	Treatment.	Yield of paddy.	Series.	Treatment.	Yield of paddy.
		Grains.			*Grains.*
I	Check	5.1	X	Sulphate of ammonia and acid phosphate	5.8
II	Nitrate of soda and sulphate of potash	5.8	XI	Sulphate of ammonia and Thomas slag phosphate.	6.5
III	Nitrate of soda and muriate of potash	5.9	XII	Fish guano and acid phosphate	5.2
IV	Sulphate of ammonia and sulphate of potash	7.0	XIII	Fish guano and Thomas slag phosphate	5.3
V	Sulphate of ammonia and muriate of potash	5.6	XIV	Acid phosphate and sulphate of potash	5.7
VI	Fish guano and sulphate of potash	7.3	XV	Acid Phosphate and muriate of potash	*a*
VII	Fish guano and muriate of potash	5.8	XVI	Thomas slag phosphate and sulphate of potash.	5.4
VIII	Nitrate of soda and acid phosphate	6.0	XVII	Thomas slag phosphate and muriate of potash	*a*
IX	Nitrate of soda and Thomas slag phosphate	5.9	XVIII	Equivalent proportion of each element in each of the forms represented above	*b*

(*a*) Weight in doubt. (*b*) Plants failed to mature.

SUMMARY.

In the 1907 direct fertilizer experiment, one pot of each series had been limed and one drained, while the third received no other treatment than the application of fertilizer. In the direct fertilizer experiment, the limed pots in every series showed some depression, varying from 14 to 40 per cent in the decreased yield of straw and paddy. In the residual experiment no such depression was noticeable due to liming, the lime evidently having been neutralized in the meantime. All the pots of a series showed uniformity in growth. It could not be noticed that draining the pots exerted any influence upon the yield. The loss of fertility due to leaching was apparently insufficient to influence the growth.

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[a] Hawaii Sta. Rpt. 1907, p. 80.

The results of the experiment seem to indicate that the largest residual value was derived from the fish guano and sulphate of potash (Series IV). The next best result seemed to have been obtained from sulphate of ammonia and Thomas slag phosphate (Series XI), nitrate of soda and acid phosphate gave better results than sulphate of ammonia and acid phosphate (Series VIII), nitrate of soda and muriate of potash, and nitrate of soda and Thomas slag phosphate, gave equal results (Series III and IX). It is difficult to understand why the fish guano in combination with acid phosphate and Thomas slag should have given the poorest results in the whole experiment, while the fish guano and phosphate gave good results in other combinations.

From the above experiment, it would appear that considerable residual value may result from the application of moderate quantities of some of the commercial fertilizer materials, even when applied to the previous crop before planting.

In residual experiment the quick maturing Japan Seed derived little or no benefit when the preceding crop was fertilized before planting, but the more vigorous and slowly maturing Gold Seed showed increased yields up to 34 per cent under the same treatment. However, when the previous crop was fertilized after the crop was three-fourths grown, material benefit was derived by both the Japan Seed and Gold Seed, the strong growing Gold Seed receiving the greatest benefit.

So far as the two experiments are comparable, there is agreement in the general principle involved, i. e., that chemical fertilizers may exert influence upon succeeding crops and that such influence depends upon the amount and period of its application. It may further be concluded :

(1). That nitrogen in sulphate of ammonia, and in the organic form; phosphoric acid in the water soluble, reverted and tetra calcic forms; and potash as a sulphate and a muriate, may exert residual value when applied in sufficient quantities before planting the preceeding crop, the stronger and more vigorous growing variety deriving the greater benefit.

(2). That the same fertilizers, in like quantity, applied to the crop first preceding when well advanced in growth, will exert a considerably greater residual benefit upon the succeeding crop than if applied before planting.

It has already been determined in a former experiment, that, with the single exception of nitrate of soda, fertilizer materials exert the greatest benefit to the immediate crop when applied before planting.

Thus may we conclude that, while fertilization before planting benefits the immediate crop most, the greatest residual benefit is derived from fertilizers applied to the previous crop when well advanced in growth.

Thus it will be seen that each method has an advantage as well as a disadvantage. The relative economy of the two methods of fertilization has not yet been determined, but from the experimental data thus far accumulated, and from the well-known fact that the spring crop is naturally the lighter where two crops are grown annually, and responds most to fertilization, it would seem that liberal applications of fertilizers applied to the spring crop, before planting, would produce the maximum spring yield and carry over sufficient residue to give a maximum fall crop without additional fertilizer, or, if a stimulant should be needed as the fall crop advances, a light application of sulphate of ammonia or nitrate of soda might be applied at the drying off period preceding the flowering stage. An experiment is now under way to determine these points.

Experiment III. Direct Fertilizer Experiments.

Three tests to compare the relative value of several commercial forms of nitrogen as fertilizers for the rice crop were made during different seasons of the year.

The subjoined table gives the results of the first series of these tests together with the results obtained from green manure, stable manure, and the complete rice fertilizer recently formulated by the station.

This series of tests was made under identical season, soil, and cultural conditions, so that the results are comparable and represent the yield of paddy from 100 clumps of rice.

Relative value of various forms of nitrogen for rice.

Plat Number	Fertilizer applied.	Amount per Acre	Height of plants at maturity.	Green weight whole plants	No. of culms per clump of five plants.	Weight of paddy	Date of maturity.
		Pounds.	*Inches,*	*Pounds.*		*Pounds.*	
I	Check (no fertilizer)...	....	33–35	45	15–20	5.3	July 20
II	Complete fertilizer *a*	350	38-40	48	20-22	7.1	July 22
III	Stable manure............	5000	40–45	55	21–23	6.8	July 25
IV	Complete fertilizer *b*	350	40–43	51	20–25	7.9	July 20
V	Check.......	....	34–35	46	17–20	5.7	July 22
VI	Green manure............	20000	40–48	60	20–25	5.9	July 30
VII	Sulphate of Ammonia	200	44–48	64	25–27	8.1	July 25
VIII	Lime Nitrogen..	266	38–42	50	22–24	6.7	July 25
IX	Check..........................	....	30–34	44	16–18	5.2	July 20
X	Nitrate of soda...........	266	35–38	47	20–22	5.9	July 28

a. Applied when the crop was two-thirds grown.
b. Applied before planting.
Balance of fertilizers, except stable manure and green manure, applied to crop when two-thirds grown.

SUMMARY.

In the test of the nitrogenous fertilizers, nitrogen was applied at the rate of 40 pounds per acre, when the crop was one-half to two-thirds grown, the materials being applied broadcast upon the receding flood water which precedes the drying off period, a short time before the rice comes into bloom. (See Pl. IV).

The increase in yields of paddy over untreated plats was as follows: With sulphate of ammonia, 50 per cent; lime nitrogen, 24 per cent; nitrate of soda, 9.2 per cent.

The green manure (legumes and weeds) yielded only 9 per cent increase in paddy, but a large increase in straw, the small yield of paddy being due to an excessive rankness of growth, in which the seed set poorly. The green manure was applied at the estimatel rate of 20,000 pounds per acre, and was worked into the submerged soil just previous to planting, as is the custom in Oriental countries, and it is probable that the material was applied at too short an interval before planting, or in quantities excessive for the amounts of mineral matter available.

A further observation illustrates the danger of excessive green manuring.

The green manure plat showed rankness in growth especially along the outer rows, adjoining the dikes where an extra amount of vegetation had unavoidably accumulated.

The first and outer row failed to set fruit, although it flowered and tillered freely; the second row showed less rankness, and seeded fairly well. Irregular ripening characterized the fruiting panicles; rows 3 to 5 were fairly uniform in height, fresh weight, yield of paddy, and maturity.

Compared with the results obtained from sulphate of ammonia, the green manure produced plants of about equal height, but less tillering, slower maturity and less uniformity. The 5,000 pounds stable manure per acre gave 26 per cent increase in yield of paddy. The complete fertilizer yielded 31 per cent increase when applied to the crop two-thirds grown, and 46 per cent when applied before planting. This latter fertilizer supplied 17½ pounds of nitrogen per acre.

EXPERIMENTS IV AND V.

In experiments 4 and 5 the comparative value of different forms of nitrogen for Japan and Hawaiian Gold Seed rice and for different varieties of Japan rice was tested. In each case the yield of 100 clumps of rice was taken. The acompanying tables give the results of the experiments:

Relative value of commercial forms of nitrogen as fertilizers when applied to Japan Seed and Hawaiian Gold Seed rice.

	Amount per acre.	Japan Seed.		Hawaiian Gold Seed.	
		Yield of paddy.	Increase.	Yield of paddy.	Increase.
	Pounds.	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
Check (average of 3 plats)	....	2.6	....	3.1	....
Nitrate of soda	266	2.8	7.6	3.3	6.4
Sulphate of ammonia	200	4.1	57.6	5.2	67.7
Lime nitrogen	266	3.0	15.8	4.1	32.2

Relative value of different commercial forms of nitrogen as fertilizers when applied to various types of Japan rice at an early stage of growth.

Variety No.	Fertilizers applied (equivalent of 40 pounds nitrogen).						
	Check. (average of 2 plats).	Sulphate of ammonia.		Nitrate of soda.		Lime-nitrogen.	
		Yield of paddy.	Increase overcheck.	Yield of paddy.	Increase overcheck	Yield of paddy.	Increase overcheck.
	Pounds.	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
144	2.15	2.94	37	2.30	7	2.64	22
161	4.06	6.00	48	4.54	12	5.30	31
163	4.50	6.47	44	5.35	19	5.80	28
165	5.20	7.33	41	5.93	14	6.62	28

In both these experiments, the sulphate of ammonia proved the most beneficial, lime nitrogen second, and nitrate of soda third. These results are in agreement with the former test.

In experiment 4, the Japan and Gold Seed were grown under identical conditions, but the Japan Seed matured in 110 days while the Gold Seed matured in 140 days. This longer period of growth after fertilization evidently acted favorably in the case of the sulphate of ammonia and the lime nitrogen, but made little or no difference in the case of the nitrate of soda.

Thus it would appear that the maximum benefit from nitrate of soda may be secured from a comparatively late application, while the sulphate of ammonia, and especially the lime nitrogen, require a considerably longer period in which to exert their maximum power. Furthermore, it is evident that when applied in large quantities, either early or late, but a small percentage of the nitrogen in nitrate of soda is taken up by the plant.

FERTILIZER EXPERIMENTS ON DRYLAND RICE.

The fertilizer tests upon dry-land rice resulted in indefinite results as regards the yield of paddy, owing to the unusually dry season. However, on both the silty loam of the station grounds and the gravelly loam of the rice trial grounds the muriate of potash, sulphate of ammonia, and nitrate of soda increased the yield of straw in the order named. The other constituents applied in the same forms and amounts as shown in table on page 71, appeared to exert no influence.

CO-OPERATIVE EXPERIMENTS WITH A COMPLETE FERTILIZER

Three cooperative tests with a complete fertilizer were undertaken on three separate plantations.

The fertilizer was of the following composition:

5 per cent nitrogen—2 per cent as organic (fish guano and dried blood), 3 per cent as sulphate of ammonia.

9 per cent phosphoric acid—4 per cent as acid phosphate, 5 per cent as reverted phosphate.

12 per cent potash as sulphate of potash.

The fertilizer was applied at the rate of approximately 350 pounds per acre. This is equivalent to 17.5 pounds nitrogen, 31.5 pounds phosphoric acid, and 4.2 pounds potash per acre. The cost of this mixture in the Honolulu market is about $50 per ton, hence the cost of fertilizing, including transportation and application, approximates $10 per acre.

The results from these experiments were as follows:

At Punaluu Plantation, Oahu, which has been continuously under rice since 1872, the average yield on 37 acres has been less than 74,000 pounds paddy per spring crop. Five tons of the above formula was applied to the 37 acres, and the increased yield of paddy, covering the whole area, was estimated at 35 per cent over the average of former crops.

Valuing the paddy at $2.25 per hundred pounds and making a liberal allowance for the cost of fertilization, a net profit of $6 per acre was obtained upon the first crop. As the fertilizer was applied to the crop when it was two-thirds grown, a considerable residue should be conveyed to the subsequent crop.[a]

In a second experiment adjoining the rice trial grounds at Waikiki, a one-year fallow paddy field was set to Hawaiian Gold Seed on March 2. On May 1, the complete fertilizer was applied to half the field at the rate of 350 pounds per acre. The crop was harvested the latter part of June with the following results: Unfertilized, 2,950 pounds paddy per acre; fertilized, 4,100 pounds paddy per acre.

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[a] For former experiments conducted on this plantation, see Experiments V, VI, VII, Hawaii Sta. Rpt. 1907.

This gives an increase in yield of 39 per cent, which is equivalent to a net profit of $15 per acre after deducting $10 for fertilization.

In a supplementary test adjoining the above experiment, 200 pounds sulphate of ammonia (40 pounds nitrogen) gave an increased yield of 50 per cent over the unfertilized plats, an increase of 5 per cent over the plat receiving complete fertilizer. From this we may conclude that a higher percentage of nitrogen in the complete fertilizer would have yielded better results.

A third cooperative experiment yas conducted at Palama Plantation near Honolulu. The paddy field used had been cropped for twenty years and represented the poorer "kula" lands (uplands immediately bordering the better lowlands). The average yield was said to be less than 1,800 pounds paddy per acre. The complete fertilizer was applied to the crop shortly after planting, at the rate of between 350 and 400 pounds per acre. The estimated increase in yield was between 75 to 100 per cent over the unfertilized field. Owing to the crop being cut before a representative of the station arrived, no actual weighings could be made. The estimate was made by the planter. Based upon the results of this experiment, the station was called upon to plan a scheme for the systematic fertilization of the whole plantation.

UPLAND RICE AS A HAY AND GRAIN CROP.

The experiments with upland rice grown under minimum amounts of irrigation water are now in their second year and have given results which are summarized below.

Of the eight or ten varieties of upland rice entering into the first comparative tests, all have been eliminated except variety No. 68 (S. P. I. Inv. No. 17917), a dwarf, bearded rice from northern China, which matures in 100 to 115 days; variety No. 65 (S. P. I. Inv. No. 17144), a strong growing smooth hulled, beardless type, of Egyptian origin, extensively known in Louisiana as "Bull Rice"; No. 154a, a Porto Rico upland rice resembling the Gold Seed; and possibly No. 19 (S. P. I. Inv. No. 12508), the Ceylon rice described under variety tests, and which promises well under ordinary submerged culture.

A spring, summer, and fall planting gave the following mean results:

Summary of mean results obtained with a minimum amount of water upon upland rice.

Variety.	Method of planting.	Length of growing season.	Total water received. (irrigation and rainfall)	Yield of paddy.	Yield of hay (approximate)
		Days.	*Acre Inches.*	*Pounds.*	*Pounds.*
No. 19 (S. P. I. Inv. No. 12508)	Drilled	190	47.0	......(*a*)	10,000
No. 65 (S. P. I. Inv. 17144)	"	143	30.6	5,014	9,926
No. 68 (S. P. I. Inv. 17917)	"	109	23.5	2,080	5,920
No. 68 (S. P. I. Inv. 17917)	Aftermath	34	5.9	......(*b*)	2,240
No. 154 (*a*)	Drilled	145	30.0	......(*b*)	5,000

In the above data, the rainfall is included with the irrigation water, which was applied bi-weekly at the rate of approximately 2½ acre inches per application. This is equivalent to about 0.2 inches per day during the growing period.

When double the above amount of water was used, i. e., 2½ acre-inches weekly, the yield of hay was increased from 20 per cent in the case of varieties Nos. 65 and 68, up to 50 per cent with variety No. 19; but the grain was not increased proportionately.

When grown under submerged conditions, the yields of both paddy and hay failed to exceed those receiving weekly irrigations of 2½ acre-inches. With half the minimum amount of irrigation represented in the foregoing table, i. e., 2½ acre-inches once in four weeks, all the varieties suffered severely and failed to make a crop.

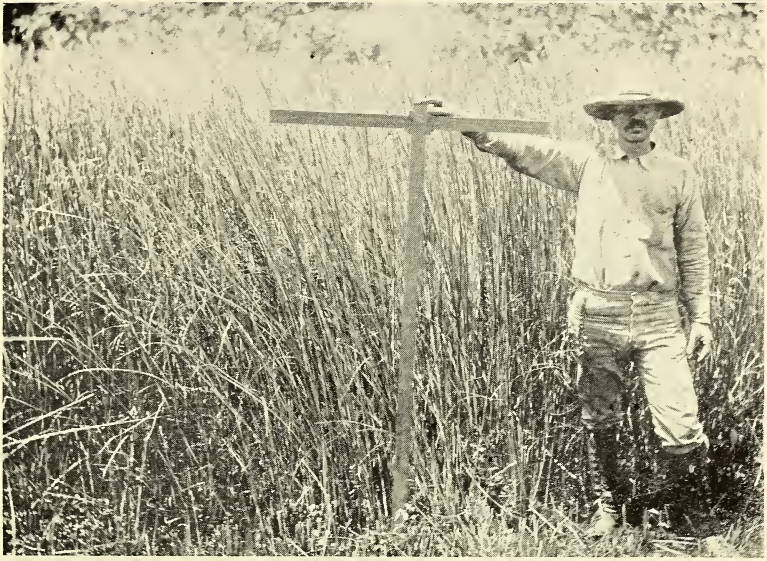
From the above we may conclude that 2½ acre-inches of water every two weeks during the growing season is the minimum moisture which will insure a paying crop, and the 2½ acre-inches of water weekly is near the optimum.

Two factors of equal importance in insuring a crop under a minimum water supply are deep and thorough tillage and light seeding. In a well tilled field, drilled at the rate of 60 pounls seed per acre, without irrigation, all the varieties failed to reach the fruiting stage under 10 inches of rainfall. However, when seedlings of the quick maturing variety No. 68 were thinned so as to stand 6 to 12 inches apart, in drills 8 inches apart, the plants tillered well and produced perfect seeds. Where the plants stood eight to the running foot, very little tillering occurred and only an occasional glume bore sparingly of seed. With sixteen seedlings to the running foot of drill (approximate stand from 60 pounds seed per acre), the plants entirely failed to set seed.

(*a*) Failed to set seed well.

(*b*) Not estimated.

PLATE VI. Fig. 1. Chinese mat rush, *(Cyperus tegetiformis)* five months from planting



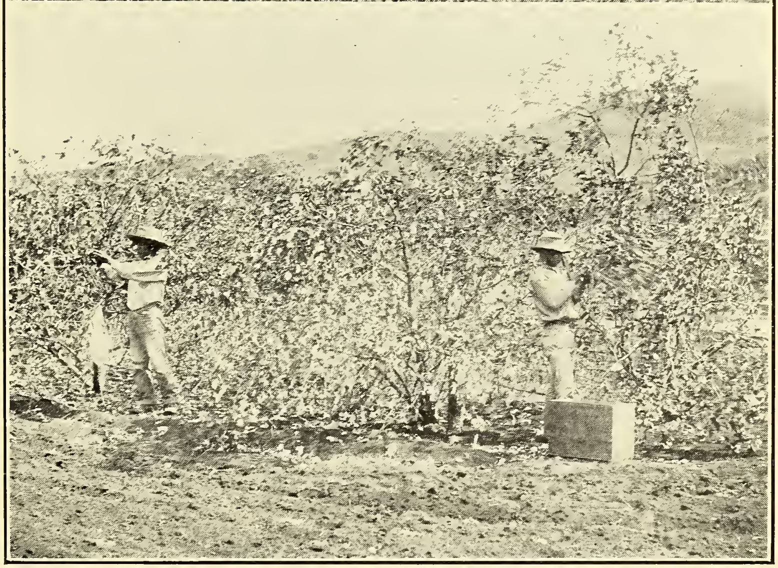


Fig. 2. Caravonica tree cotton at Hawaii Experiment Station.

Where the soil was poorly prepared, the plants made a much poorer growth than where the tilth was good. Under good tillage the development of the root system of one plant was equal to that of four to six plants in poorly prepared soil. The same relative development was true of plants set well apart and those that were crowded.

From this we may conclude that it is essential that the seed bed be thoroughly prepared and that the seed be sown thinly. The importance of this becomes greater as the supply of moisture becomes smaller.

Chemical analysis of the different varieties of rice entering into these experiments will be found in the report of the assistant chemist.

SALT-MARSH RICE AS HAY.

The price of imported cereal hays, exceeds $20 per ton, and the total importation is 10,000 tons, valued at a quarter of a million dollars annually. This fact has induced the station to devote some attention to developing a home-grown substitute. Much hope is entertained for upland rice in this regard. It has been further suggested that the inferior types of rices, such as the salt-resisting marsh varieties, which are now much used as adulterants in the standard sorts, might be utilized as a cured fodder for horses and cattle.

The following data have been obtained from an experimental harvest. Early in the spring an acre of growing marsh rice of average stand and quality was secured, adjoining the trial grounds.

The grain was in the milk stage May 20, when the flood water was drained from the field. On May 22 the ground was sufficiently firm to bear the weight of a man and the first cutting was made. Four days later most of the grain had entered the dough stage and another cutting was made. By May 30, most of the grain began to harden and the last harvest was made.

Calculated to acre yields, the following results were obtained:

Total green weight	14,212
Total air cured matter as hay	5,852
Total as cured paddy	2,842

At $25.00 per ton, the gross value would be $73.15 per acre as cured hay; and rating the paddy at $2 per 100 pounds, (a high price for this variety), its value would be $56.84 per acre.

The cost of harvesting for hay or grain would be about equal. The cost of curing and baling as hay should not exceed the cost of threshing and bagging the paddy. No special difficulty was experienced in securing a well cured hay, although the grain was found to shatter badly in the lot harvested when fully ripe. (See Pl. V).

Extensive feeding experiments have not yet been undertaken. However, it has been found that some horses feed greedily upon the well cured hay from the start, while others merely nibble the grain. The writer has fed a half ton to a horse and a cow with success, and the Chinese rice growers feed it almost exclusively to their horses; frequently they feed the straw alone.

Estimating the salt-marsh lands of Oahu now devoted to this type of rice at 1,000 acres, and allowing $10 increase revenue per acre by cutting the crop as hay, $10,000 per crop or $20,000 per annum could be added to the profits of the rice growers. A number of practical feeding tests are to be undertaken this fall.

CHINESE AND JAPANESE MAT RUSH EXPERIMENTS.

The species represented in these experiments are *Cyperus tegetiformis,* the Chinese mat rush (Seaside grass, Pl. VI), and *Juncus effusus,* the Bingo-i mat rush of Japan. Three plantings and three harvests have thus far been completed at the rice trial grounds near Honolulu, and a first planting at Kailua, on the windward side of Oahu. Each succeeding crop has been better than the previous one and the following results represent our best yields. In three average cuttings of 100 square feet each the Chinese mat rush yielded cured reeds at the rate of:

	Pounds per Acre.
60 inches and over	8,712
48 to 60 inches	5,762
36 to 48 inches	5,227

It required between 6 and 7 months for the spring crop to mature from direct planting. The fall crop matures in about 5 months when grown from rattoons. This second crop does not attain the length of the planted crop but the stand is more dense. The crop at Kailua is not yet mature, but promises well.

Sample reeds of the Chinese rush have been forwarded to a matting factory and reports as to quality are expected shortly. The Japanese mat rush has greatly improved during the past year and presents a fine appearance at this writing. A large stock of plants have been propagated and it is planned to set out several acres during the coming fall.

The greatest obstacle in the way of making the growing of the Chinese rush a profitable crop in Hawaii appears to be the large expense attached to preparing the rushes for market. Each reed requires to be split lengthwise before curing.

COTTON EXPERIMENTS.

Stray cotton plants appear in many parts of the Hawaiian group. As long ago as 1856, F. A. Oudinot reported[a] upon a cotton tree growing at Lahaina, Maui, which was said to be fifteen years old at that time. The variety is stated to be the Sea Island. Several attempts have been made to grow cotton upon a commercial scale, but the industry was never developed. Renewed interest at this time is very pronounced. A first variety test of cotton was made by the station in 1905-6. The quality of several of the varieties was favorably reported upon by the fiber experts of the U. S. Department of Agriculture and also by manufacturers.

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[a] Trans. Roy. Hawaii Agr. Soc., 2. (1860), No. 3, pp. 104-106.

A number of three-year-old pants of the Caravonica type are still growing on the station grounds and bear a fair quality of cotton. A recent experimental picking yielded 15 pounds seed cotton from a single plant. The plants bear continuously throughout the year. Some of the plants are being cut back to determine the influence of pruning. The kidney, silk, and wool Caravonica plants at the station are now three years old. (See Pl. VI). The plants will average at least 5 pounds per tree, and two such pickings can be made annually.

Beginning in March of the present year, a variety test was undertaken with two strains of Sea Island, two types of Caravonica, and a Chinese type of upland cotton. At the end of the fiscal year, June 30, the Sea Island was well in bloom and all the varieties were doing finely.

SOY BEANS.

The soy bean possesses many advantages as a green manuring or rotation crop. Early in the present year, three varieties of soy beans were obtained through the Bureau of Plant Industry. These were designated at Nos. 20797, 20798, and 21080. All were supposedly tall-growing varieties, which had been introduced into the Southern States as fodder and green manuring crops. Seed of two other varieties were donated by the Hawaiian Yamajo Soy Company of Honolulu. One of these, a green seeded type, has been grown in the Kona district of Hawaii for some years; the other, a yellow seeded variety, was imported direct from Japan. The seed of both of these varieties is used in the manufacture of the Japanese food product, "Miso," and other preparations.

All the varieties were sown on March 12. Variety No. 21080, which proved to be a dwarf type suitable for shelled beans, and the two Japan sorts matured in about 100 days from planting, (see Pl. VII, fig. 2). Planted in drills 12 by 18 inches apart, the following yields of shelled beans per acre were obtained:

Variety No. 21080, 600 pounds of shelled beans per acre; imported Japan, 800 pounds; and Kona seed, 1,060 pounds.

The plants of the above varieties are very dwarf, average less than 12 inches in height, and are upright in growth. It seems likely that closer planting, say 6 inches apart in the drill, will give material increase in yields. The average price in the Honolulu market is $3 per hundred pounds. About 500 tons of the beans are imported from Japan annually, and the demand is said to be on the increase.

It would appear that this could be made a profitable crop for the small farmer. The plant requires little moisture, but responds well to thorough hand tillage, which permits of close planting. Careful selections have been made and it is hoped that more prolific strains will be developed.

The tall-growing varieties are making a vigorous growth and have attained a height of from 10 to 30 inches. (See Pl. VII, fig. 1), The plants appear to be very irregular in size and maturity, as if the types had not been established. Two hundred pods have been counted on single plants, while others have not come into flower. All the varieties appear to be well supplied with root nodules.

PEANUTS.

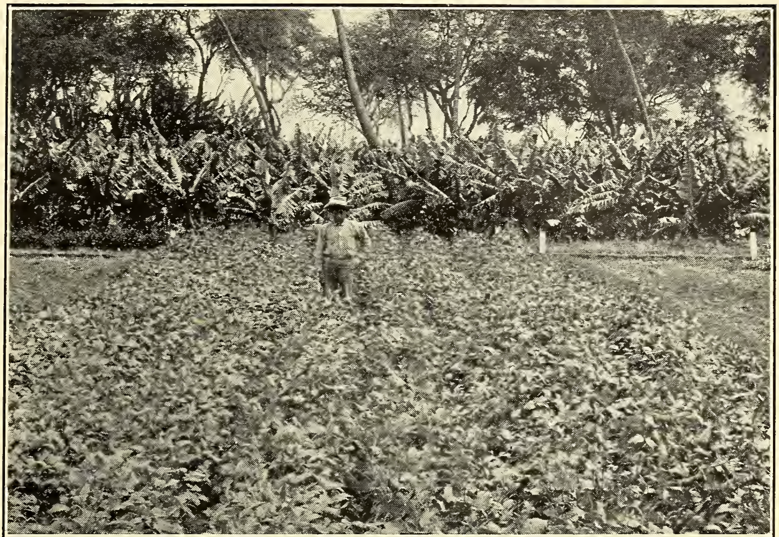
Variety and cultural tests of the following varieties of peanuts are now under way: Spanish, Bunch Jumbo, Running Jumbo, and Virginia Running. Three types of soil at different elevations, and with varying amounts of soil moisture are being considered. Planted April 20, the varieties are making fine growth and flowering profusely June 30. The plants have made a spread of fully 4 feet.

LEGHORN WHEAT.

A small quantity of seed of the wheat, the straw of which is used in the manufacture of the Italian Leghorn hats, was received under the name "Corn, Suta Fiore."

Drilled in rows 12 inches apart on March 23, the culms attained a height of 36 to 40 inches up to June 30. The plants tiller well and appear to require about as much moisture as upland rice.

PLATE VII. Fig. 1. Plat of Soy Beans



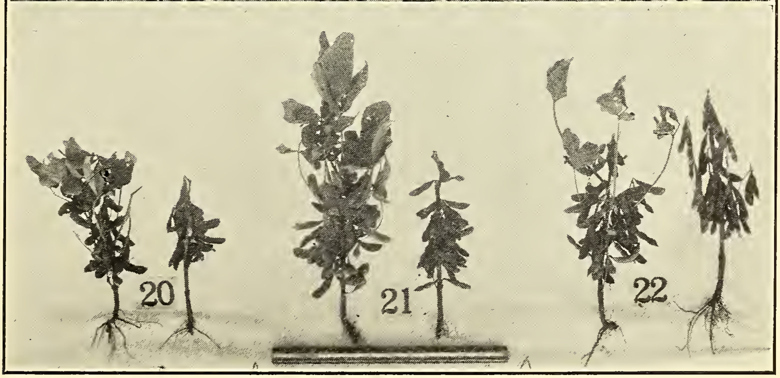


Fig. 2. Dwarf Soy beans, used in making "Miso" and other Japanese food products.